Economy-wide material flow accounts, foreign trade analysis, and derived indicators for the EU

"Resource use and material flow accounts"

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Contents, figures and tables

Aim of the study ................................................................. 1
Policy context ................................................................. 2
Executive summary .......................................................... 4
1. Methodology development of MFA towards economic branch accounts ....................... 29
   1.1. Allocation of disaggregated material input flows to branches after the NACE rev.1 classification .......................................................... 29
   Allocation of domestic material input flows ......................................................... 29
   Allocation of imports and indirect flows associated with imports ......................... 31
   Allocation of indicators (DMI, TMR) ................................................................. 34
   1.2. Breakdown by major material categories ..................................................... 37
   1.3 Ranking of NACE branches according to their TMR and/or DMI “load” .............. 43
   1.4. Allocation of material output flows to NACE rev.1 sectors ............................... 45
   Exports and TMR of exports by economic sectors .............................................. 45
   Material outputs to the environment by economic sectors ..................................... 47
   Emissions to air ......................................................................................... 47
   Emissions to water .................................................................................. 50
   Waste deposition ...................................................................................... 50
   Dissipative material outputs ........................................................................... 52
   Disaggregation of economic sectors by relevance for material outputs ................. 52
   Data availability and recommendations for improvement ..................................... 55
2. Cross-country comparison of MFA of the EU, Member States, and Non-EU countries inclusive Accession Countries ................. 57
   2.1. Cross-country comparison with regard to Direct Material Input (DMI) ............... 58
   2.2. Cross-country comparison with regard to Direct Material Consumption (DMC) .... 74
   2.3. Cross-country comparison with regard to Total Material Requirement (TMR) ........ 89
   2.4. Material productivities of DMI, DMC and TMR by cross-country comparison .... 98
       Productivity of DMI ............................................................................... 99
       Productivity of DMC .......................................................................... 104
       Productivity of TMR .......................................................................... 109
3. Globalization and trade .......................................................... 112
   3.1. Analysis of long time series of EC/EU imports and exports in physical and monetary terms, including indirect resource requirements in physical terms ................. 112
       Imports and exports in relation to GDP and DMI ....................................... 113
       The composition of physical imports ......................................................... 116
       The composition of physical exports ......................................................... 117
       Physical and monetary trade balances and prices ........................................... 118
       Total material requirements of imports ...................................................... 122
       Total material requirements of exports ...................................................... 123
       Physical trade balances with and without indirect flows ......................... 125
   3.2. Analysis of foreign trade parameters of the EC/EU with respect to origins of imports and destinations of exports ............................................ 126
       Foreign trade by income classes and with indebted countries ....................... 128
       Foreign trade with developing and newly industrializing countries ............... 133
       Foreign trade by geographical regions ......................................................... 141
       Foreign trade by economic regions ............................................................ 147
       Foreign trade by major trade partners ........................................................ 151
       Imports of trade goods ........................................................................... 154
       Imports of pollution intensive commodities .............................................. 157
3.3. Analysis of land use for imports, exports and domestic consumption of agricultural commodities of the EU

Land use for imports and exports – overview

Land use for imports and exports by materials

Land use for imports and exports by regions and countries

Land use by income classes and level of external debt

Land use by developing countries and newly industrializing countries

Land use by geographical regions

Land use by economic regions

Land use by major trade partners

Land use for domestic consumption of agricultural commodities

Land use of the EC/EU on the global scale

Conclusions and recommendations

Acknowledgement

Annex

Table 1: Domestic extraction used for Germany 1991 to 2000 allocated to economic branches (NACE 2-digits)

Table 2: Unused domestic extraction for Germany 1991 to 2000 allocated to economic branches (NACE 2-digits)

Table 3: Imports allocated to receiving economic branches (NACE 2-digits) and categories of final demand, Germany 1991-2000

Table 4: Indirect flows associated to imports allocated to receiving economic branches (NACE 2-digits) and categories of final demand, Germany 1991-2000

Table 5: DMI allocated to economic branches and categories of final demand, Germany 1991-2000

Table 6: TMR allocated to economic branches and categories of final demand, Germany 1991-2000

Table 7: Domestic versus foreign shares DMI and TMR, Germany 1991-2000

Table 8: Material input flows by major material categories

Table 9: TMR – Fossil Fuels, Germany 2000

Table 10: TMR – metal ores, Germany 2000

Table 11: TMR – industrial minerals, Germany 2000

Table 12: TMR – construction minerals, Germany 2000

Table 13: TMR – Biomass, Germany 2000

Table 14: Ranking of the contribution of economic branches (NACE 2-digits) to DMI of Germany 1991 to 2000

Table 15: Ranking of the contribution of economic branches (NACE 2-digits) to TMR of Germany 1991 to 2000

Table 16: Exports, their indirect or hidden flows, and total resource requirements (TMR) for Germany 2000 vs. 1991 attributed to major material aggregates and economic sectors (NACE 2-digits)

Table 17: Emissions to air for Germany 1995 attributed to economic sectors (NACE 2-digits), and comparison with MFA data for Germany

Table 18: Emissions to water for Germany 1991-2000 attributed to economic sectors (NACE 2-digits)

Table 19: Waste disposal for Germany 1995 attributed to economic sectors (NACE 2-digits), and comparison with MFA data for Germany

Table 20: Dissipative outputs for Germany 1991-2000 attributed to economic sectors (NACE 2-digits)
Table 21: Ranking of the contribution of economic sectors (NACE 2-digits) to exports of Germany 1991 to 2000.

Table 22: Ranking of the contribution of economic sectors (NACE 2-digits) to the TMR of exports of Germany 1991 to 2000.

Table 23: Ranking of the contribution of economic sectors (NACE 2-digits) to material outputs to the environment of Germany 1991 to 2000.

Table 24: International data availability for DMI.

Table 25: International data comparison for DMI (for notes see Table 24).

Table 26: Major components of DMI and their contributions to changes over time periods studied (for notes see Table 24).

Table 27: International data availability for DMC.

Table 28: International data comparison for DMC (for notes see Table 27).

Table 29: Major components of DMC and their contributions to changes over time periods studied (for notes see Table 29).

Table 30: International data availability for TMR.

Table 31: International data comparison for TMR (for notes see Table 30).

Table 32: Major components of TMR and their contributions to changes over time periods studied (for notes see Table 30).

Table 33: Resource productivity of DMI.

Table 34: Resource productivity of DMC.

Table 35: Resource productivity of TMR.

Table 36: Physical and monetary trade balances of the EC and EU from 1976 to 2000.

Table 37: Importprices and Exportprices of the EC and EU from 1976 to 2000.

Table 38: Importprices divided by Exportprices of the EC and EU from 1976 to 2000.

Table 39: Physical trade balance of the EC/EU 2000 by material groups and change vs. 1976.

Table 40: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for countries income classes and for severely indebted countries and highly indebted poor countries.

Table 41: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for developing countries outside Europe, least developed countries, and newly industrializing countries (NIC) in Europe (incl. and excl. CPE) and outside Europe.

Table 42: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for geographical regions.

Table 43: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for economic regions.

Table 44: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for single countries.

Table 45: Agricultural land use related to foreign trade of the EC/EU 1990-2000 with economies classified by income and external debt.

Table 46: Agricultural land use related to foreign trade of the EC/EU 1990-2000 with economies classified by development.

Table 47: Agricultural land use related to foreign trade of the EC/EU 1990-2000 by geographical regions.

Table 48: Agricultural land use related to foreign trade of the EC/EU 1990-2000 by economic regions.

Table 49: Agricultural land use related to foreign trade of the EC/EU 1990-2000 by major trade partners.

Table 50: Agricultural land use account of the EC/EU 1990-2000 in the global context.
Aim of the study

The aim of this study was to contribute to sub-action 7 "Resource use and material flow accounts" of the Environmental Accounts Action of EUROSTAT by:

(1) contributing to the further development of economy-wide Material Flow Accounts (MFA) by accounting for the contribution of economic sectors to material inputs and outputs, in particular with regards to the NAMEA methodology and structure,

(2) performing cross-country analysis to test the usefulness and informative capability of MFA data and indicators for the EU, Member States and Non-EU countries with particular focus on Accession and Candidate Countries of the EU, in the course of economic development, and in order to derive policy-relevant information from the accounts,

(3) analysing international trade flows of the EU and related environmental effects in terms of resource use and land use over time and with respect to regional distribution in the course of increasing globalisation.

The Commission is provided by this study with:

(a) a methodology on the further development of MFA towards analysis of the contribution of economic sectors to economy-wide material flows, including draft NAMEA-type tables for material flows,

(b) analytical evaluation of changes and drivers of changes of resource use and materials productivity for the EU in comparison with Member States and Non-EU countries with particular focus on Accession and Candidate Countries of the EU, in particular for Direct Material Input (DMI), Direct Material Consumption (DMC), Total Material Requirement (TMR), and related materials’ productivities,

(c) data sets in time series on international trade of the EU comprising values (EURO) and quantities (tonnes) of commodities, as well as estimated indirect material requirements and land use associated with imports and exports of agricultural commodities to and from the EU; the data sets being further differentiated by national economies with focus on major trade partners of the EU, economic regions, geographical regions, and specific country groupings for income level, degree of external debt, and development status. From these data sets, net trade balances of values, material requirements, and land use were derived. For land use the data set was expanded by accounting for the total agricultural land area required for domestic consumption of agricultural products in the EU (derived from domestically available agricultural land plus land use associated to imports minus exports associated land use).
Analyses and interpretation of the accounts and indicators, including cross-country analysis and econometric analysis, are general major issues in this study in order to develop and demonstrate their usefulness for providing policy-relevant information to the Commission. The study was conducted in close cooperation with EUROSTAT, in order to facilitate the further use of the methodology, data and indicators.

The study is divided into 3 major chapters:

1. Methodology development of MFA towards sector accounts;
2. Cross-country comparison of MFA of the EU, Member States, and Non-EU countries with particular focus on Accession and Candidate Countries of the EU;

**Policy context**

The issue of consumption and production patterns was particularly addressed as a policy matter during the United Nations Summit on Environment and Development in Rio 1992. It was then recognised that the current consumption and production patterns, especially those in the developed economies, were unsustainable and had to be changed. One promising approach is to increase the resource-efficiency of economic activities and processes, i.e., to produce more welfare with less associated use of resources.

The importance of the issue was confirmed ten years later, in August 2002, during the World Summit on Sustainable Development in Johannesburg. It was decided to establish a ten-year Framework Programme to “accelerate the shift towards sustainable consumption and production to promote social and economic development within the carrying capacity of ecosystems by addressing and, where appropriate, de-linking economic growth and environmental degradation, through improving efficiency and sustainability in the use of resources and production processes, and reducing resource degradation, pollution and waste” (UN 2002).

In the European Union, the issue of resource use has also been put on the political agenda. The European Union’s Strategy for Sustainable Development (CEC 2001a) emphasised the strategic objective to break the link between economic growth, the use of resources, and the generation of waste.
Furthermore, the 6th Environment Action Programme of the European Union (CEC 2001a) identified Sustainable Use of Natural Resources and Management of Waste as one of the priority areas. The specific objectives for this area are: (CEC 2001b, p. 50, 53):

(1) to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment; and

(2) to achieve a de-coupling of resource use from economic growth, through significantly improved resource efficiency, dematerialisation of the economy, and waste prevention.

As part of the work plan, the Community has recently published a communication entitled 'Towards a Thematic Strategy on the Sustainable Use of Natural Resources' (Commission of the European Communities 2003b). Citation: “This Communication is a first step towards the Thematic Strategy on the Sustainable Use of Natural Resources (Resources Strategy), called for in the EU’s Sixth Environment Action Programme. It aims to launch a debate on a framework for using resources which supports the objectives of the Lisbon strategy and the EU’s sustainable development strategy. After analysing the environmental issues associated with the use of natural resources, it outlines the main features that a future strategy should comprise, building on existing policies. Although it sets out basic ideas on how the EU should target its efforts to reduce the environmental impacts of resource use, it does not actually propose specific measures to this end. This will be done in the final strategy to be presented in 2004.” (Citation from: Commission of the European Communities 2003b, p.4).

Through the necessary analysis, data collection and evaluation, the goal is to identify priority areas of policy concern as well as propose best mix of policy instruments to address the identified issues.
**Executive summary**

The present report comprises three different subject areas: methodology development of MFA towards economic branch accounts (chapter 1), cross-country comparison of MFA (chapter 2), and globalization and trade (chapter 3). These three areas are summarized separately in the following. However, they are clearly interlinked with each other as pointed out in the study. In general, these interlinkages can be illustrated as follows:

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**Methodology development of MFA towards economic branch accounts (chapter 1)**

A methodology was developed and described for allocating material inputs to economic branches after the NACE Rev.1 nomenclature and categories of final demand, and illustrated by applying it to MFA data for Germany. This comprises domestic extraction and harvest and associated hidden flows, as well as imported and exported commodities and associated indirect flows, i.e. DMI, TMR and TMR of exports of an economy. Further analytical development was suggested by attributing material inputs to major material groups (fossil fuels, construction minerals, industrial minerals, metals, and biomass) and major material aggregates (material requirement in foreign economies, domestic extraction and harvest, direct material requirements, hidden or indirect material flows). These allocations provide the basis for further analysis by input-output techniques and modelling to account for material intensities of producing sectors and final demand.

Sector accounts for material outputs to the environment were analyzed based on available data for Germany by the Federal Statistical Office Germany (emissions to air and waste...
deposition). Furthermore, sector accounts for emissions to water and dissipative material outputs to the environment were developed in this study, providing a comprehensive sector allocation of Domestic Processed Outputs (DPO, and of TDO – Total Domestic Output - by including domestic hidden flows accounted for under material inputs). For emissions to air and waste deposition, existing sector accounts were further analyzed with regards to compatibility with requirements for consistent economy-wide material balances as determined by the Eurostat methodological guide on economy-wide MFA, and solutions were elaborated on how to derive this compatibility from the available data. Furthermore, obvious data gaps in common environmental statistics were identified, these concern mainly emissions to water, dissipative material outputs to the environment, and – most critically – final waste deposition, and recommendations were formulated on how to fill the data gaps. Concerning final waste deposition, data requirements were discussed under the light of ongoing activities of the European Topic Center on Waste and Material Flows at EEA (ETC-WMF), and related to the EC thematic strategy on the prevention and recycling of waste, and the EC regulation on waste statistics. To meet the objectives of the EC thematic strategy on the prevention and recycling of waste (Commission of the European Communities 2003a) quantitative as well as qualitative data and information on final disposal of waste is required. The EC regulation on waste statistics (EC 2002) provides the basis for this kind of information by the Statistical Offices within the EU and Eurostat. The European Topic Center on Waste and Material Flows at EEA (ETC-WMF) established an electronic database for waste (WasteBase) which includes waste quantities, policies, plans, strategies, and instruments. Further development should aim at providing more comprehensive and consistent information on waste flows in Europe on the level of economic branches and with a focus on final waste disposal, in particular waste deposition, to meet the requirements of economy-wide material flow analysis as a tool for providing comprehensive information to decision makers.

Finally, further sectoral disaggregations were suggested (beyond NACE Rev.1, 2-digits) for providing more detailed policy relevant information on the distribution of DMI, TMR, exports, TMR of exports, and major aggregates of DPO, based on rankings for dominant economic branches influencing both the level and trend of resource use and material outputs to the environment.

Cross-country comparison of DMI, DMC, and TMR (chapter 2)
Cross-country comparison of DMI, DMC, and TMR was performed based on all data available in time series, by absolute levels of the indicators in the most recent year, their changes over the time periods, foreign shares and their developments for DMI and TMR, share of DMC of DMI and its development over time, resource use on a per capita level, and indicators by major components identifying and analyzing major reasons and drivers of changes over time. Furthermore, the material productivities of DMI, DMC, and TMR were compared for the available data sets in absolute terms, as changes over time, relative to the productivities of the EU, and for trends of decoupling or coupling with GDP including analysis for major reasons and drivers of decoupling or coupling trends. In general, cross-country comparisons comprised Non-European countries (incl. China, Japan, USA), the EU-15 and its Member States, Accession and Candidate Countries of the EU, and Iceland and Norway, depending on varying data availability for the aggregated indicators and detailed related data and information.

All indicators data sets were analyzed at first for consistency. Major differences and data gaps were pointed out, and in the case of multiple data sources (for the EU-15 and Member States) the source was selected which was in best agreement with the standards set by the Eurostat guide on economy-wide MFA, giving further preference to data sets published by national statistical offices (e.g. for Italy). Also, relative informative capabilities of DMI, DMC, and TMR were compared and discussed.

**DMI:**

*DMI per capita* of the EU-15 ranks in the midfield of 43 economies studied with 19 t/cap in 1997, its Accession and Candidate countries have little lower DMI per capita with descending order from AC-10 (16 t/cap), over AC-12 (14 t/cap) to AC-14 (11 t/cap). Their accession to the EU will therefore most probably indicate slightly lower values of the direct material inputs per capita of the European Union. This assumption is further supported by the observation that the DMI per capita of the AC increased only slightly during 1992 to 2000, close to the stabilization of DMI per capita of the EU-15 over 1980 to 1997.

The EU-15 as a whole ranks also in the lower midfield as regards the *imports share of DMI* (18%), close to the same ratios for its Accession and Candidate countries as entire economies with about 19% to 20%. Especially the newly industrializing economies (NIC) of Eastern Europe got increasingly involved in foreign trade after transition of their economies in the early 1990s. This is in agreement with results showing increasing imports by the EU from NIC over that period (see chapter 3). The EU-15 had increased its imports share of DMI at a
relatively low average annual rate (factor 0.06) from 1980 to 1997. This was much less than found for its Accession and Candidate countries at factor 0.18 p.a. in AC-10, and factor 0.16 p.a. for both AC-12 and AC-14. So, despite of similar shares of imports of DMI in the late 90s, the accelerated development especially in the Eastern European AC shows a possible trend towards higher relative global direct material requirements from abroad in an extended EU, which does not necessarily mean that DMI in absolute terms will increase as well.

The total contribution of non-renewable materials (fossil fuels and minerals) to DMI ranged from as low as 13% in Latvia to as high as 91% in Italy and Egypt. The EU-15 required two thirds (66%) of its DMI by non-renewables, in AC-10 the share of non-renewables of DMI was 68%, in AC-12 67%, and in AC-14 63%, very close to the situation in the EU. Clearly, economies with a relatively high share of non-renewable materials are likely to require significantly more efforts in order to proceed towards a more sustainable development. However, also the resource use by renewable materials (biomass) should be further analyzed critically with regards to unsustainable modes of production due to environmental pressures associated like minerals fertilizer and pesticides use in agriculture, unsustainable forestry management, and unsustainable fishing practices.

In total, non-renewables (fossil fuels and minerals) contributed by only as little as 13% to the overall change of DMI in the Netherlands, but by as much as 95% to DMI change in Norway. Change of DMI of the EU-15 was by 44% caused by non-renewables, respective changes in AC-10 by 67%, in AC-12 by 74%, and in AC-14 by 68%. So, DMI of the Accession and Candidate countries was found to be significantly more influenced by non-renewable material requirements, and their development appears under this aspect as less sustainable than development of the EU. However, for the reasons discussed before, also the contribution of renewables to overall changes of material use has to be analyzed under a critical view.

For the EU-15 and its Member States it can be clearly seen that the domestic construction industries and domestic agriculture play most important roles for the development of DMI, as well as the energy demand supplied via imports. Also, the material demand of metal manufacturing industries via imports and for biomass via imports deserves consideration in this respect. So, policies for sustainable development in the EU have to consider especially the fields of energy demand, constructions, manufacturing of metals, and agriculture.

The situation in the Accession and Candidate Countries of the EU is somehow in between developing and industrialized economies. Their DMI is, like in developing countries, largely driven by domestic primary industries, especially construction minerals, fossil fuels, but also
the forestry industry deserves special attention in this respect in the Baltic States (Estonia, Latvia, Lithuania). In contrast to industrialized economies, a smaller part (6 of 14) of these mostly newly industrializing economies increased their absolute DMI via imports. These are Hungary and Poland due to increased demand of metals manufacturing industries, Malta due to increased demand of minerals manufacturing industries, and Latvia, Slovakia, and Turkey due to increased energy demands by fossil fuels. If further development in the NIC of Eastern Europe will bring about a similar situation as in the EU, this will most probably lead to increasing direct material requirements supplied via imports.

However, the analysis for changes of DMI should be considered as providing incomplete information only. It should be supplemented by inclusion of the hidden flows of domestic extraction or harvest and of the indirect or hidden flows of imports, i.e. the Total Material Requirement (TMR). TMR allows analysis for the comprehensive material basis of an economy on a comparable level for domestic extraction and foreign resource requirements.

**DMC:**

**DMC per capita** of the EU-15 ranks in the lower midfield among 42 economies studied with 18 t/cap DMC in 1997, its Accession and Candidate countries showed significantly lower domestic material consumptions per capita with descending order from AC-10 (14 t/cap), over AC-12 (12 t/cap) to AC-14 (10 t/cap). Their accession to the EU will therefore most probably indicate slightly lower values for the domestic material consumption per capita of the European Union. This assumption is further supported by the observation that the DMC per capita of the AC had remained constant during 1992 to 2000, like in the EU-15 over 1980 to 1997.

The EU-15 as a whole ranks high as regards the **DMC share of DMI** (95%), above the same ratios for its Accession and Candidate countries as entire economies with about 85% to 87%, indicating that most of the EU’s direct material requirements is due to domestic consumption of goods, and that some increase of absolute DMC in an extended EU may be expected assuming that the AC will strive for a similar share of DMC of DMI.

Most of the economies studied, i.e. 27 of 37, showed a similar trend of DMC and DMI. So, for 10 of 37 economies, the trend of DMC was different as compared with DMI. Of these ten economies, 3 economies, i.e. the Netherlands, Latvia, and Slovakia, had even reduced their DMC whereas their DMI had increased over the same period. For these economies, direct material resource management aiming only at reducing DMC would thus have only limited effect on the reduction of their direct material requirement. This shows that DMC may have
limited capability as an indicator for materials management, and should not be used as sole indicator in this respect. The remaining seven economies for which the trends of DMC and DMI were also different include the EU-15 (DMI constant, DMC decreased) and AC-12 (DMI increased, DMC constant).

The total contribution of non-renewable materials (fossil fuels and minerals) to DMC ranged from as low as 13% in Latvia to as high as 95% in Italy. The EU-15 required about two thirds of its DMC by non-renewables, the same share as for DMI (66%). In AC-10 the share of non-renewables of DMC was close to the share in the EU (70%), also in AC-12 (69%), and in AC-14 (64%), also close to the ratios found for DMI of the AC. However, also the resource consumption by renewable materials (biomass) should be further analyzed critically with regards to unsustainable modes of production of consumption goods.

In total, non-renewables (fossil fuels and minerals) contributed by only as little as 16% to the overall change of DMC in Norway, but by as much as 96% to DMC change in Cyprus. So, patterns of DMI and DMC changes in Norway point towards opposite directions, DMI change is determined by non-renewables, but DMC change by renewables. This illustrates the potential shortcoming if only one of the two material flow indicators is considered, for example as sole headline indicator for the economy’s direct resource use. Change of DMC of the EU-15 was by 57% caused by non-renewables, respective changes in AC-10 by 83%, in AC-12 by 89%, and in AC-14 by 76%. So, like DMI, DMC of the Accession and Candidate countries was found to be significantly more influenced by non-renewable material use. However, for the reasons discussed before, also the contribution of renewables to overall changes of material consumption has to be analyzed under a critical view.

For the EU-15 and its Member States it can be clearly seen that mostly a combination of the domestic consumption of fossil fuels, construction minerals, and agricultural products induced the overall changes of DMC. Constructions mostly contributed to increases of DMC (except in the Netherlands and in the UK), the same holds for agricultural products (except in EU-15 and France). The role of fossil fuels consumption is more diverse, in five Member States (Belgium and Luxembourg, France, Germany, and the UK) and in the EU-15 it contributed to reduce DMC, whereas in 5 Member States (Denmark, Finland, Greece, Portugal, and Sweden) fossil fuels consumption contributed to increase DMC.

The situation in the Accession and Candidate Countries of the EU is somehow similar to the EU-15 and its Member States, and mostly construction minerals and fossil fuels led to changes of DMC whereas agricultural products played a significant role only in AC-12 and
Turkey. In the AC, domestic consumption of forest products and industrial minerals induced changes of DMC in more economies than consumption of agricultural products did. Constructions were, however, the most important inducer of increasing DMC in most of the economies of AC-14. Planning of infrastructure and housing development in the AC-14, thus, appears as the priority area for managing direct material consumption. The role of fossil fuels for the AC is not as diverse as described for the EU and its Member States. In eleven economies of AC-14, domestic fossil fuels consumption had decreased during the 1990s, and in only two economies (Cyprus and Turkey) it had contributed to increase DMC. If the trend towards less fossil fuels consumption could be continued, this should be a promising way towards more sustainable consumption of direct material resources in the AC.

As discussed for DMI, the analysis of driving constituents for changes of DMC should be considered as providing incomplete information only. It should be supplemented by inclusion of the hidden flows of domestic extraction or harvest and of the indirect or hidden flows of imports and exports, i.e. the Total Material Consumption (TMC). Only TMC allows comprehensive analysis for major implications and the effects of driving changes on the overall material consumption of an economy on the global scale. This should be subject of a follow-up study. So far, TMC data are scarce and development of internationally comparable TMC accounts should be fostered by Eurostat and DG Environment, as well as by national statistical offices and environmental institutions.

**TMR:**

On a per capita basis, Finland had the highest TMR per capita with 99 tons per capita in 1999, followed by USA (86 t/cap in 1994), Germany (72 t/cap in 2000), Denmark (70 t/cap in 1997) and the Netherlands (67 t/cap in 1993). The high absolute TMR of China corresponds to a TMR per capita of 38 t/cap in 1996. A lower TMR per capita was found for Poland and Hungary (about 32 t/cap each in 1997). TMR per capita was also relatively low for Italy (39 t/cap in 1998), for the UK (44 t/cap in 1999), and for Japan (45 t/cap in 1994). TMR of the EU-15 ranged in the midfield at about 51 tons per capita in 1997.

Like for absolute TMR, also TMR per capita had increased relatively most in China at 6% per year on the average from 1990 to 1996. Similarly, high absolute TMR as well as per capita increases of TMR were found especially for Spain, Hungary, Poland, Denmark and Finland. Among the 15 economies studied, only the Czech Republic, the U.S., and Germany had achieved significant decreases of their TMR per capita over the periods studied. TMR per capita of the EU-15 had remained rather constant from 1980 to 1997.
The share of foreign total material requirements of TMR was highest in the Netherlands, Italy, Japan, and Denmark. These four countries had sourced most of their total material requirement in other economies, the Netherlands and Italy even about two thirds. All other 11 economies relied more or less predominantly on domestic total material resources, the EU-15 by 59% in 1997. China’s TMR in 1996 was almost exclusively based on domestic resources (by 99%), and also the U.S. required only 7% of its TMR in 1994 from abroad. Moderate foreign contributions to TMR were found for Spain (20%), Hungary (21%), Poland (23%), and the Czech Republic (26%).

The share of foreign material requirements was significantly higher for TMR than for DMI in 12 economies reporting on TMR. Only in China, USA, and Hungary the opposite situation was observed. This underlines the statement made before, that TMR has to be considered in order to derive more representative information on the distribution of material requirements between domestic and foreign sources.

Most of the economies studied had increased their shares of imports of TMR over the observation periods, indicating the increasing globalization in terms of accelerated foreign trade especially during the 1990s (see also chapter 3). The only country that had decreased its foreign TMR share was Spain (factor 0.8 from 1996 to 2000). West Germany and Hungary had rather stabilized their foreign TMR share over the reporting periods. Most pronounced average annual increases of this ratio were found for Poland (0.38), China (0.37), and Hungary (0.25). Thus, especially newly industrializing economies (NIC) got increasingly involved in foreign trade after transition of their economies during the 1990s. The high increase of foreign TMR of China must be seen under the aspect that the absolute share of foreign TMR is very low at 1%. However, if the rate of increase will continue, i.e. a doubling in 5 years, China will increasingly put pressure on global material resources. Also the EU-15 had increased its foreign TMR share from 1980 to 1997 by 1.3 times whereas its overall TMR had remained almost constant, indicating increasing shift of environmental pressures to foreign countries. This was analyzed in detail in chapter 3.

The total contribution of non-renewable materials (fossil fuels, minerals, excavation, and erosion) to TMR ranged from 72% in Finland to 97% in China, a much more narrow range than observed for DMI and DMC, indicating that the relevance of non-renewables for resource use may be severely neglected by relying on direct material flow indicators only. The EU-15 required 87% of its TMR by non-renewables, also a significantly higher share than for DMI (66%) and DMC (44%), indicating that total non-renewable material use in the EU is associated with overproportional shares on hidden or indirect flows. In Japan (93%) and in the
U.S. (91%) the non-renewables shares of TMR were even higher than in the EU. Thus, all economies studied were found to have a relatively high share of total non-renewable materials and require substantial efforts in order to proceed towards more sustainable total material resource use on the global scale. This result further puts into perspective the findings for DMI and DMC with regard to the higher share of renewables of those indicators; in addition, accounting only for direct use of renewable materials (biomass) does not consider side effects of agricultural production leading to considerable losses by soil erosion and, thus, (at current rates) irreversible loss of productive land, an example for an unsustainable mode of production.

In total, non-renewables (fossil fuels, minerals, excavation, and soil erosion) contributed by 74% to the overall change of TMR in Finland and in the Netherlands, and by 97% to TMR change in China, again a much more narrow range than observed for changes of DMI and DMC. Change of TMR of the EU-15 was by 92% caused by non-renewables, respective changes in Japan also by 92%, and in the U.S. by 91%.

As regards drivers of changes of TMR, domestic construction industries have to be addressed mainly in China, Japan, the EU, Spain, Poland and Hungary. In China and in Poland, excavations of earth for constructions are major points for action. In the other four economies, construction minerals industries have to be addressed mainly in this respect.

Other main actors to be addressed for reducing TMR are industries depending on imported metals, this is the case in the EU, Denmark, Finland, Spain and in the UK.

Further, the fossil fuels demand by imports represents a major field of action in Japan, the Netherlands, Spain and in the UK.

The analysis of driving forces for increasing TMR underlines clearly, as for DMI and DMC, the high relevance of domestic construction industries and fossil fuels demand. It points in addition to DMI and DMC to the increasing importance of metals manufacturing industries depending mainly of material resources in foreign countries. In this respect, especially the EU and its Member States are concerned. In order to strive for global sustainable development by reducing total material requirements and their environmental impacts, it is thus not sufficient to consider DMI and DMC only, but TMR has to be taken into account as well.

Material productivities:

Most of the economies studied had a lower DMI productivity than the EU-15. However, relative to the GPD/DMI ratio of the EU-15, Japan had a 2.2 times higher DMI productivity in
the same year, and also Austria, France, and Germany ranked above the DMI productivity of the EU as a whole. Contrary, especially Estonia, Cyprus, Bulgaria, Latvia, and Bolivia had significantly lower DMI productivities than the EU in the same year that ranged at about one tenth of GDP/DMI of the EU-15. Special attention has to be payed to the low DMI productivities of the Accession and Candidate Countries of the EU. In order to reach the same level as the EU, their DMI productivities would have to be increased by factor 5.2 for AC-10, factor 5.6 for AC-12, and factor 4.5 for AC-14, an enormous challenge for these (mostly) newly industrializing economies in the future.

Most of the economies studied, including the EU-15 and the Accession and Candidate countries as whole economies, had achieved relative decoupling of DMI from economic growth in terms of GDP. However, considerable efforts are required to achieve further decoupling of DMI from GDP growth in almost all economies. To this end, targets should be considered with regards to the extent of increase of DMI productivity over a set future time period and in relation to a target year in the past. Consequently, based on targets for increasing the material resource productivity of the economy, strategies for increasing the DMI resource productivity, as well as resource productivities for DMC, TMR and TMC, have to be developed and integrated into policies for sustainable development. The European Commission’s recent approach “Towards a Thematic Strategy on the Sustainable Use of Natural Resources” (Commission of the European Union 2003b) is a promising first step towards this goal in the European Union. However, the results described before clearly indicate that integration of the Accession countries will require enormous additional efforts.

Most of the economies studied had also a lower DMC productivity than the EU-15. However, relative to the GPD/DMC ratio of the EU-15, Japan (2.2 times) and Norway (2.0) had significantly higher DMC productivities in the same year, and also Belgium/Luxembourg, Denmark, France, Germany, the Netherlands, and the UK ranked above the DMC productivity of the EU as a whole. Contrary, especially Bolivia, Egypt, Cyprus, Estonia, Latvia, Lithuania, Bulgaria, and Romania had significantly lower DMC productivities than the EU in the same year that ranged at about one tenth of GDP/DMC of the EU-15. Special attention, as for DMI productivities, has to be payed to the low DMC productivities of the Accession and Candidate Countries of the EU. In order to reach the same level as the EU, their DMC productivities would have to be increased by factor 4.6 for AC-10, factor 5.1 for AC-12, and factor 4.1 for AC-14, an enormous challenge for these (mostly) newly industrializing economies in the future. The situation of the AC as regards DMC productivity is thus the same as found for DMI productivity, indicating that domestic consumption of
(direct) materials is the dominating use of the direct material inputs in these economies (though still at lower relative share than in the EU).

In most of the 38 economies studied, relative decoupling of DMC from GDP occurred over the periods studied, including the EU and most of its Member States, but also the Accession and Candidate countries of the EU in total.

The comparison of DMI and DMC productivities revealed that economies with both high direct material use and high exports achieve of course significant better DMC than DMI productivity. This puts light on a necessary critical evaluation of productivity measures for economies. The authors conclude that DMC as the sole indicator for material productivity bears the risk that economies with high exports get overevaluated in so far as the environmental burden that they put on the global environment by requiring high amounts of direct material inputs needed to produce commodities for export thus gets out of sight. The recommendation rather has to be that a combination of productivity measures is needed, comprising DMI and DMC as well as TMR and TMC, to account for the comprehensive material resource requirement respectively consumption of an economy. Comparative analysis will then unveil to which extent an economy is based on export oriented economic growth, and in how far an economy is based on global material resource intensive production and consumption for achieving economic wealth.

Most of the economies studied had a lower TMR productivity than the EU-15. However, relative to the GDP/TMR ratio of the EU-15, Japan had a 2.1 times higher TMR productivity in the same year, and also Denmark, and Italy ranked above the TMR productivity of the EU as a whole. Contrary, especially China, the Czech Republic, Poland and Hungary had significantly lower TMR productivities than the EU in the same year that ranged from factor 0.03 for China to factor 0.31 for Hungary. Special attention has thus to be payed to the low TMR productivities of the three Accession Countries of the EU in 2004 reporting so far on TMR. In order to reach the same level as the EU, their TMR productivities would have to be increased by factor 6.5 for the Czech Republic, factor 4 for Poland, and factor 3.2 for Hungary, a similar enormous challenge for these newly industrializing economies in the future as found for DMI and DMC productivities. The challenge is even much higher for China which requires an increase of TMR productivity by factor 29 to reach the level of the EU-15.
In most of the 15 economies studied, *relative decoupling of TMR from GDP* occurred over the periods studied, including the EU and most of its Member States, but also China, Japan, the U.S. and Poland.

The analysis shows that considerable efforts are required to achieve further decoupling of TMR from GDP growth in almost all economies studied. To this end, targets set for the increase of DMI productivity have to be extended in order to achieve reduction of environmental pressure on the global scale. In this respect, only the inclusion of hidden or indirect flows by TMR provides information on the extent of foreign total resource requirements. National sustainability strategies as well as the European Commission’s recent approach “Towards a Thematic Strategy on the Sustainable Use of Natural Resources” (Commission of the European Union 2003b) should consider the material productivity of TMR as well as the productivities of DMI, DMC and TMC as discussed before, in order to consider major relevant aspects of material resource requirements for production and consumption.

*Globalization and trade of the EC/EU (chapter 3)*

A comprehensive analytical database for globalization and trade of the EC/EU was developed based on the foreign trade statistics of Eurostat, and on the database for hidden or indirect flows coefficients of the Wuppertal Institute. Additional information was included from several sources for extended classifications of economies by income level, external debt, development status, geographical regions, and economic regions, as well as for identification of pollution intensive commodities imports. Furthermore, own aggregation of commodity groups was performed to point out major material groups of imports and exports.

Foreign trade of the EC/EU was studied in complete time series available from the Eurostat statistics, from 1976 to 2000, comprising absolute amounts of physical and monetary imports and exports, indirect (physical) flows associated, derived trade balances (imports minus exports) and prices, and with particular foci on physical imports of trade goods, pollution intensive commodities, and imports of commodities from developing countries and newly industrializing countries in Europe exhibiting outstanding rising importance.

Furthermore, land use associated with imports and exports of agricultural commodities was analyzed based on coefficients derived from FAO statistics and the database of the Wuppertal Institute, and discussed in the context of total land use for domestic consumption of agricultural goods in the EC/EU as compared with the global average.
Trade by materials

The monetary commodity imports and exports both increased significantly from 1993 to 2000 in the EC/EU, a clear indication of increasing involvement of the EC/EU trade in the course of increasing globalization that was reported to be most expressed during the 1990s (Enquete Commission 2001). The increases of the monetary imports and exports – and to a lesser extent - also of the physical exports were clearly higher than respective developments of the whole economy – expressed as GDP and Direct Material Input (DMI = Imports plus domestic raw materials extraction). This can be interpreted as a clear evidence for a globalization effect.

The composition of physical imports of the EC/EU showed a remarkable constant structure during the entire observation period of 25 years. About three fourths of the physical EC/EU imports are raw materials. Among 14 commodity groups, the dominance of minerals fuels is obvious, with a constantly high share of 54% to 63% of all commodities. Second range ores (and concentrates) with 10% to 16%. Also the commodity groups minerals excl. ores (3-4%) and wood (4-6%) represent raw materials or commodities with a low degree of manufacturing. These four commodity groups account for more than three fourths of the physical imports of the EC and EU.

From 1995 to 2000 the physical imports of the EU-15 increased by 13%. A major part of this increase (48%) was due to increased imports of mineral fuels, followed by wood (12%). Minerals excl. ores contributed only little to this increase (2%), and imports of ores even decreased in absolute terms from 1995 to 2000.

About two thirds of the physical EC/EU exports since 1981 are raw materials, a similar situation as for imports (however, the physical trade balance of raw materials shows a clear surplus of imports). Minerals fuels constitute – as for imports – the dominant commodity group with 23% to 34% of all commodities exports. Next range metallic products with shares between 16% and 26%, nutritional goods with 10% to 22%, minerals excl. ores with 7% to 13%, and chemicals with 8% to 11%. Also wooden products (2% to 8%) and mineral products (2% to 4%) hold notable shares of the total export of commodities. Thus, the composition of the physical export appears more complex than the one of imports, and commodity groups (at the 2-digits level of Nimexe and CN) whose individual share is less than 2% of total exports in tonnes, together account for 15% to 16% of all exports. Still, mainly raw materials and semi-manufactured products contribute most to the total amount of exports – the same as for imports.
From 1976 to 2000 physical exports increased by about 128%, from 1999 to 2000 stepwise by ca. 7%. This relative increase was even more than that of physical imports (plus 51%) during the same period. As for imports, mineral fuels contributed mainly (by 26%) to the increase of physical exports. Next range nutritional goods (22%), followed by wooden products (12%), and metallic products (11%).

During the period 1976 bis 2000 the EC/EU constantly had a clear surplus of imported commodities in tonnes, the physical trade balance (PTB) ranged between 531 million and 1 billion tonnes with an increasing tendency. Mineral fuels contributed most to this increasing surplus of imports (67% to 76%), followed by metals (10% bis 20%). The imbalance of imports and exports increased from 1976 to 2000 by 32%. Except for biomass, for which a declining trend of PTB is observed, the physical foreign trade balances of the major material groups all increased from 1976 to 2000.

The monetary trade balance (MTB) shows surpluses of exports between 1993 and 1998, and surpluses of imports from 1976 to 1992 (except 1986) and in 1999 and 2000. Over the entire period, the MTB of metals and other products shows surpluses for exports, surpluses are observed constantly for the MTB of biomass and mineral fuels, whereas the MTB of minerals varies between surpluses of imports and exports. The monetary balances amount to at most 22% of the total volumes of imports and exports (which are almost equal by numbers), they are therefore by far lower than the physical balances (up to 400% of the total amounts of exports).

Thus, the EC/EU constantly requested physically more materials by global trade than it provided to the rest of the world (not considering indirect flows at this point). Imported commodities were rather of low value and low manufacturing level, whereas exports were rather of high value and high manufacturing level.

Average prices for imports of the EC/EU rose from 1976 to 2000 from 0.2 to 0.7 ECU per kg. Least expensive were mineral fuels at 0.08 to 0.18 ECU per kg. Most expensive were metals at up to 2.1 ECU per kg and other products.

Prices for exported commodities by the EC/EU increased on the average from 1976 to 2000 from 0.8 to 2.2 ECU per kg. Also for exports, mineral fuels were cheapest at 0.09 to 0.25 ECU per kg. Metals were the most expensive material group for export at 1.7 to 6.4 ECU per kg.

The total price ratio of imports to exports was relatively constant at 0.2 to 0.3 over the whole period 1976 to 2000. Imports were always cheaper than exports as concerns the material
groups metals, minerals and mineral fuels. Occasionally in between 1976 and 2000, biomass and other products were imported at higher average prices than those for exports.

The composition of the total material requirement (TMR) associated with imported commodities by the EC/EU showed a more complex picture than for absolute physical imports which were clearly dominated by mineral fuels. In 2000, the TMR of imported mineral fuels (25% of total TMR) ranked only second after the TMR of ores (29%), and also the TMR of metal products (19%) and that of mineral products (15%) contributed significantly to the total TMR of imports of the EC/EU. Thus, TMR reveals material resource requirements for commodities that are imported after relatively resource and waste intensive steps of processing and manufacturing leaving high amounts of unused extraction and processing wastes in the countries of origin.

From 1976 to 2000 the total material requirement (TMR) associated with imported commodities by the EC/EU almost doubled from 4.4 to 8.6 billion tonnes. Most of this increase was assigned with imported ores (45%), followed by mineral fuels (26%), metal products (18%) and mineral products (10%), the four commodity groups also contributing most to TMR in absolute terms. The pattern of total material resource requirements by imports of the EC/EU appears therefore rather conservative even over a period of 25 years, and the highly resource intensive demands even increased most, indicating negative development of the respective import dependent economic sectors in the EC/EU with regards to reducing their global resource requirements and associated environmental impacts.

The average ratio of TMR to absolute imports was 6:1 in 2000, so, every tonne of imported commodity leaves an equivalent of 5 tonnes indirect or hidden flows in the countries of origin. The highest ratio of TMR to absolute imports in 2000 was observed for mineral products (144), followed by metal products (20), and ores (17).

The composition of the total material requirement (TMR) associated with exported commodities by the EC/EU showed a similar picture as for absolute physical exports, with the most obvious exception that the TMR of mineral products increases its rank considerably over its rank among absolute exports. In 2000, the TMR of metal products contributed most to TMR of exports (31%), indicating that the high TMR for imported ores had been required by metal manufacturing sectors in the EU producing (also) commodities for exports. Next to metal products follow contributions of mineral products to TMR (20%), nutritional and related commodities (18%), and mineral fuels (14%). Thus, total material resource requirements for imported and exported commodities show a relatively similar picture as
regards the focus on non-renewable materials. A major difference represents the relatively high contribution of nutritional commodities to the TMR of exports as opposed to imports, indicating the relative importance of agricultural and derived production in the EC/EU.

From 1976 to 2000 the total material requirement (TMR) associated with exported commodities by the EC/EU increased from 1.5 to 2.3 billion tonnes, but values fluctuated from an intermediate high of 2.4 billion tonnes in 1987 until 2000 between values of 1.7 billion tonnes in 1988 to a maximum of 2.6 billion tonnes in 1993. So, in contrast to imports, there is no clear trend for the TMR of exports by the EC/EU during the period 1987 to 2000. Still, all over the 25-years period, the four commodity groups mineral fuels, metal products, mineral products, and nutritional commodities dominate the TMR of exports, a similar conservative pattern as observed for the TMR of imports. It shows that the total material resource requirements of these highly resource intensive exporting sectors in the EC/EU hardly changed and overall exports of the EC/EU did not proceed towards a less material resource intensive development.

The average ratio of TMR to absolute exports was almost 16 in 2000, considerably more than that of imports (6). So, exported commodities of the EU required much more material resources than imports, leaving respective amounts of processing wastes and unused extraction within the EU.

From 1976 to 2000 the EC/EU had a clear and increasing surplus of physical imports in absolute terms of up to 1 billion tonnes (PTB, see before). This surplus increases significantly for the indirect or hidden flows associated with imports and exports (PTB of indirect or hidden flows) which reaches a maximum of 5.3 billion tonnes in 2000. The same results for the total material requirement (PTB of TMR: absolute amounts of imports minus exports, both inclusive their indirect or hidden flows) which went up to a maximum of 6.3 billion tonnes in 2000 – from about 3 billion tonnes during 1976 to 1987. This increase of the TMR of PTB occurred in two periods, from 1984-1989 and from 1994-2000, after a decline in between. Thus, the EC/EU required globally always and at increasing level more physical resources than it provided to the rest of the world. The inclusion of indirect or hidden flows shows that the net resource requirement which is not recorded by official foreign trade statistics is three to five times higher than the mere amount of traded commodities.

Analysis of material groups of the physical trade balance (imports minus exports) reveals that net-supplies (PTB) of the EC/EU between 1976 and 2000 were dominated by fossil fuels and metals and metal products. The increases of these groups mainly led to the overall increase of
net-imports. These two material groups also determined the global net resource requirement (PTB of TMR) and its increase from 1976 to 2000.

*Trade by countries and regions*

*By income classes and levels of external debt*, the foreign trade of the EC/EU was dominated by exchanges with middle-income countries and high-income OECD countries, for physical as well as for monetary imports and exports and their relations. Low income countries (LIC) played only a minor role as trade partner of the EC/EU, as did heavily indebted poor countries (HIPC), but for both, it is quite obvious that their share of the TMR of imports is significantly higher than the share of absolute imports, indicating overproportional total material requirements needed in LIC and HIPC to produce goods for export to the EC/EU. Severely indebted countries (SIC) showed up as main contributors to imports and especially to the TMR of imports of the EC/EU and, due to their low importance for exports of the EC/EU, SIC also contributed significantly to PTB and the TMR of PTB of the EC/EU. The monetary dimension of foreign trade of the EC/EU with SIC is indicated by the relatively low average price for imported goods and a rather low ratio of imports to exports prices. This shows that exports of poor and highly indebted countries to the EC/EU had been associated with extraordinarily total material resource requirements with associated environmental impacts at low economic benefit. From 1976 to 2000 physical imports of the EC/EU had been associated with increasing total material resource requirements abroad. This concerns especially severely indebted countries which obviously increase pressure on natural resources on their territory in order to achieve income from exports. However, their earnings from this sale of resources - as concerns the trade with the EU – are far below those of high income countries and even much lower than the average of all imports. In other words, the EC/EU imported from 1976 to 2000 increasingly cheap but resource intensive commodities especially from severely indebted countries.

In general, the same country groups by income and external debt that contributed most to the values of foreign trade parameters of the EC/EU in 2000, also contributed most to the increase of these foreign trade parameters from 1976 to 2000. Most obvious differences concerned additional contributions by high-income Non-OECD countries to the TMR of exports and to PTB. Thus, the general distribution of foreign trade of the EC/EU among countries by income classes and by external debt classes had remained rather constant over 25 years.
Developing countries outside Europe are major trade partners of the EC/EU in all aspects, and with a slightly higher relevance for direct physical imports and, even more, for the TMR of imports, a similar finding as for LIC, SIC and HIPC. Contrary, least developed countries (LDC) played only a minor role as foreign trade partners of the EC/EU, under all aspects considered in this study. LDC seem to be more or less marginalized by globalization in terms of increased global trade. Contrary, newly industrializing countries outside Europe play a significant role as trade partners of the EC/EU, similar to developing countries in total, especially with regards to the TMR of imports and the PTB of TMR. The same important role for trade with the EC/EU was found for newly industrializing countries in Europe but with the difference that NIC in Europe had a rather similar relative contribution to all parameters of foreign trade of the EC/EU, and especially did not show overproportional material resource requirements for exports to the EC/EU like their counterpart outside Europe and developing countries in total.

In general, the same country groups by development status that contributed most to the values of foreign trade parameters of the EC/EU in 2000, also contributed most to the increase of these foreign trade parameters from 1976 to 2000. Notable differences concerned, on the one hand, the role of developing countries that contributed much to absolute physical imports, but not to their increase. On the other hand, the increase of absolute physical imports was mainly due to imports from newly industrializing countries in Europe and outside Europe, which also contributed most to the increase of PTB. Apart from this significant shift of physical imports from developing countries to newly industrializing countries, the general distribution of foreign trade of the EC/EU among countries by development status had remained rather constant over 25 years.

Developing countries rather stagnated as far as their direct resource input to the EC/EU is concerned, whereas newly industrializing countries increasingly take over the role of providers of raw materials. For all three regions a clear overall change to exports of higher manufacturing levels cannot be observed, although imports of some commodity groups of relatively high manufacturing level (like railway, plastics, furniture) from developing countries and NIC had increased most of all major commodity groups, however, their contribution to the total import of the EU in 2000 was still minor.

By geographical regions, foreign trade of the EC/EU was concentrated on exchange with North- and Latin-America, the rest of Europe, The Middle East, East Asia, and North Africa. Especially Africa south of the Sahara was largely excluded from trade of the EC/EU. North America was a major trade partner in almost all aspects, but especially as regards monetary
imports, and exports in physical and monetary terms. Contrary, material resources from Latin America provided a significant source for imports and related TMR by the EC/EU. As a consequence of low physical exports of the EC/EU to Latin America, the PTB and TMR of PTB were also significant. Furthermore, the ratio of imports to exports prices for trade with Latin America was far below average. Latin America was therefore a region with similar characteristics for trade exchange with the EC/EU as described before for poor and indebted countries. With other words, these are obviously largely located in Latin America. Contrary, trade of the EC/EU with the rest of Western Europe was a major constituent for all parameters, with TMR of imports to be characterized as underproportional compared with direct imports. The latter finding also applies to imports from Central and Eastern Europe, The Middle East, and North Africa. Overall, also trade with East Asia was of high relevance for all trade parameters of the EC/EU, but most remarkable was the highest average import price for commodities from East Asia which ranged more than 6 times higher than the average, and which was even higher than the average price of commodities exported by the EC/EU to East Asia. The EU exchanged mostly high value goods with relatively low material resource requirements with East Asia, at the benefit of economies in East Asia achieving a strong monetary surplus from this trade with the EC/EU.

In general, the same geographical regions that contributed most to the values of foreign trade parameters of the EC/EU in 2000, also contributed most to the increase of these foreign trade parameters from 1976 to 2000. However, some interesting shifts can be observed. The increase of absolute physical imports was dominated by increasing imports from CIS, counterbalancing almost at the same extent decreasing imports from The Middle East, an indication mainly of the shift for fossil fuels supply since the 1980s. This influenced also the increase of the physical trade balance which was dominated by trade of the EC/EU with CIS at increasing level and with The Middle East at decreasing level. Another shift occurred for the increasing TMR of exports which was mainly due to exports to North America and East Asia, partly counterbalanced by decreasing TMR of exports to the rest of Western Europe.

Among the economic regions studied, trade of the EC/EU with OECD and APEC was most relevant under all aspects analyzed. Trade with APEC countries can be characterized the same way as trade with East Asia. Trade with the OECD is similar to this with the major difference that the monetary trade balance shows a surplus for the EC/EU whereas it is just the opposite for monetary trade with APEC. Foreign trade with OPEC countries is most relevant for direct physical imports by the EC/EU and for the positive physical trade balance. The exchange of commodities with NAFTA countries is especially characterized by high average import prices.
at relatively low material requirements, but by a high surplus of monetary trade in favour of the EC/EU resulting from relatively large quantities of physical exports to NAFTA.

In general, the same economic regions that contributed most to the values of foreign trade parameters of the EC/EU in 2000, also contributed most to the increase of these foreign trade parameters from 1976 to 2000. In agreement with the result for geographical regions, physical imports from OPEC countries (like for The Middle East) had decreased significantly from 1976 to 2000, but rising imports from mainly APEC and OECD had led to an overall increase of physical imports. Most obvious differences concerned additional contributions by MERCOSUR to the TMR of imports and to the TMR of PTB, in line with the high relevance of Latin America for these parameters. Another obvious difference was the significant contribution of EFTA to the increase of PTB.

Major trade partners of the EC/EU were in particular the U.S., Japan, Brazil, China, Russia, Norway, Switzerland, and Australia. Brazil is clearly a characteristic representative of the economies with strong features of foreign trade as described before for Latin America and indebted countries. Similarly, the U.S. represents largely trade of the EC/EU with North America. The same holds for trade with China and Japan related to East Asia, with the most obvious characteristic for Japan that import prices are on the average by factor 21 higher than for total trade. Russia obviously dominates trade of the EC/EU with Eastern Europe, as does Norway for trade with the rest of Western Europe. Trade of the EC/EU with Australia shows a remarkably low ratio of imports to exports prices resulting from low price imports of mainly raw materials from Australia and exports of high value commodities to Australia.

In general, the same countries that contributed most to the values of foreign trade parameters of the EC/EU in 2000, also contributed most to the increase of these foreign trade parameters from 1976 to 2000. Most obvious differences concerned the strongly decreasing contribution to physical imports and PTB of especially Iran, Saudi Arabia, and the United Arabian Emirates, for the reason of a shift for fossil fuel supply of the EC/EU mainly to Norway and Russia.

Raw materials which cannot, or only to a small extent, be produced domestically within the natural production system of the EU made up 85% of all raw material imports, indicating that the largest part of raw material imports of the EC/EU is meant to cover the actual requirement for resources which are as a primary resource not available domestically, and are currently not substituted by secondary (recycling based) resources or resource efficiency gains. The biggest part of these trade goods came from developing countries outside Europe (74-46%, with
clearly declining tendency and also with decreasing absolute amounts). Imports of trade goods from newly industrializing countries (NIC) in Europe were of increasing importance, from 9% in 1976 to 17% in 2000. Severely indebted countries (SIC) delivered relatively constant and high amounts of trade goods to the EC/EU at around 20%. NIC in Europe – besides severely indebted countries – more and more took over the function of delivering raw materials which cannot or only to a not sufficient extent be produced within the EU economy.

From 1976 to 2000 the EC/EU imported increasing amounts of pollution intensive commodities including fossil fuels. These commodities cause environmental pollution by production and consumption on the local, regional and global scale. The share of pollution intensive commodities represents in total 63-72% of all commodities imported by the EC/EU. A big part of pollution intensive commodities came in 2000 from developing countries outside Europe (41%), however, their share had declined strongly since 1976. OECD countries held the second largest share of 30% in 2000 with strongly increasing tendency since 1976. The same result can be observed for NIC in Europe which had a share of 24% of all imports of the EU of pollution intensive commodities in 2000, starting from 11% in 1976. Obviously, developing countries outside Europe had lost production shares for „dirty industries“ goods for the export market to the EU. However, NIC outside Europe showed a different development, they increased their share of pollution intensive imports of the EC/EU from 8% in 1976 to 15% in 2000.

From 1976 to 2000 the EC/EU imported also increasing amounts of pollution intensive commodities excluding mineral fuels. These commodities indicate environmental pollution rather by production on the local and regional scale in the countries of origin. The share of pollution intensive commodities excluding mineral fuels represents in total 6-11% of all commodities imported by the EC/EU, with clearly increasing trend from 1976 (6%) to 2000 (11%). The biggest part of pollution intensive commodities excluding mineral fuels came in 2000 from OECD countries (49%) and newly industrializing countries in Europe (41%). The share of newly industrializing countries in Europe had increased strongly from 16% in 1976 to 41% in 2000. Developing countries outside Europe contributed also a large share of 27% in 2000 that had increased since 1976 when it was only 13%. Obviously, newly industrializing countries in Europe and developing countries outside Europe produced increasingly „dirty industries“ goods for the export market to the EU, especially since the middle of the 90s. This development coincides with the period of accelerated globalization of the international economy (Enquete Commission 2002). Also, NIC outside Europe showed a similar though
less expressed development at lower absolute levels, they increased their share of pollution intensive imports of the EC/EU from 7% in 1976 to 16% in 2000.

Whether environmental pressure intensive production through emissions and wastes has been increasingly shifted, due to reduced production in the EU, to developing countries outside Europe and especially to newly industrializing countries in Europe, i.e. mainly to Eastern Europe, was not further studied here.

*Land use associated with agricultural commodities*

The EU-15 from 1995 to 2000 constantly required considerably more agricultural land (about 3 times more) for its imports than it provided to the rest of the world via exports of agricultural commodities. This was not only due to higher absolute amounts of physical imports but also due to higher specific land requirements for imported commodities than for exports. Changes of land use related import and export parameters over the period showed rather fluctuating trends at low variations. The net surplus of land requirement by imports was mainly due to raw materials and derived products demand for production and consumption. Contrary, the EU from 1995 to 2000 had always provided more land for (direct) exports of animal products than it required for imports, indicating the high economic relevance of animal production in the EU.

*The major agricultural commodities contributing to land use requirements by imports* of the EC/EU were especially oilcakes for animal feed, oilcrops (soybeans, sunflower seed) for plant oil production, as well as coffee beans and cocoa beans for manufacturing of derived products. Primary agricultural commodities for direct consumption (like fruits, vegetables) obviously play only a minor role for the overall extent of land use required for imports.

*The major agricultural commodities contributing to land use requirements by exports* of the EC/EU were especially cereals (wheat, barley), plant oils and fats, sugar, and meat and dairy products. This exports land use pattern mirrors largely the distribution of land use by commodity imports in showing the high relevance of derived products from oilseeds and animal feed. But also domestic primary crops like cereals as direct exports and sugar beets for production and export of sugar play significant roles in this context.

The distribution of *net land use for imports* underlines the high relevance of commodities for processing and animal production as described before. Obviously, the low amount of net land use for exports of the EC/EU is linked to the dominance of high yielding crops and derived products like cereals, oilseeds and sugar beets.
Land use by levels of income and indebtedness: In 2000, about half (47%) of the agricultural land associated with all imported agricultural commodities by the EU-15 was located in severely indebted countries. This finding clearly underlines results for material requirements (of all materials, not only agricultural ones) indicating that economies with high external debts can be characterized as countries providing especially resource intensive commodities for export to industrial economies. Indebtedness obviously leads to increased pressure on domestic resources in order to achieve income by foreign trade. Almost two third (64%) of the land use associated with agricultural exports of the EU-15 in 2000 was related to exports to middle income countries. The shares of poor and indebted countries are lower than for imports, however, they are still significant at 13% for LIC, 13% for SIC and 8% for HIPC, similar to the extent of land use related to exports to high income OECD countries at 15%.

Land use by development status: Developing countries outside Europe provided most of the agricultural land for imports of the EC/EU, although this relevance appears to be declining most probably due to a shift towards newly industrializing countries in Europe. This observation points to a probably lower foreign land use requirement abroad in an extended EU-25 and beyond. This should be a matter of further monitoring and more specific studies. Another remarkable result is the relatively high land use requirement of the EU for agricultural commodities in newly industrializing countries outside Europe. This may be a hint that new industrial development in these economies is largely based on natural resource intensive sectors like agriculture in this case.

Land use by geographical regions: Land use related to agricultural imports of the EU-15 in 2000 was mostly located in Latin America by 38%, North America (16%), and Western Africa and East Asia with 9% each. Most significant increases, however, were found for land use required by imports of the EU in Central and Eastern Europe, as well as in North Africa. At rather constant overall land use requirements for agricultural imports, the EU had increasingly shifted part of its requirements for land use from America, Asia, and Sub-saharan Africa to Central and Eastern Europe and North Africa. Still, America and Asia were by far bigger contributors to land use by imports of the EU in 2000 than the regions with highest rates of increase.

Land use related to exports of agricultural commodities of the EU-15 in 2000 was more evenly distributed among regions as observed for imports. The main destinations for exports land use were North Africa (18%), The Middle East (17%), East Asia (10%), Central and Eastern Europe (10%) and the rest of Western Europe (9%). Thus, the EU provides agricultural land by exports especially to those regions with relative shortage in agricultural
land availability on their own territory, i.e. North Africa and The Middle East. In general, land use for imports is strongly located in the West whereas land use for exports is mostly destined to the South and East.

Land use by economic regions: Land use related to agricultural imports of the EU-15 in 2000 was mainly located in MERCOSUR and APEC economies, whereas agricultural land provided by the EU-15 in 2000 by exports of agricultural commodities was mainly for OECD countries, APEC economies, countries of the MEDITERRANEAN BASSIN and OPEC economies. This relevance of MERCOSUR had however declined from 1990 to 2000 as regards land use for imports and even more as regards land use for exports. Contrary, agricultural land use associated with imports and exports of agricultural commodities of the EC/EU had increased most from 1990 to 2000 for trade with European OECD countries and Candidate Countries of the EU. The latter finding underlines the increasing relevance of especially Eastern European countries as trade partners of the EU in terms of natural resources during the 1990s.

Land use by major trade partners: Land use related to agricultural imports of the EU-15 in 2000 was mostly located in Brazil, Argentina, USA, Canada and Ivory Coast. The EU-15 provided agricultural land by exports in 2000 especially to Russia, Saudi Arabia, USA, Poland and Morocco. Thus, trade with agricultural commodities with the U.S. is characterized by relatively high land use in both economies. High land use provision of the EU by exports to Saudi Arabia and Morocco may be rather explained by relatively low regional availability of agricultural land per capita in these countries. The high relevance for land use by exports to Russia and Poland shows once more that foreign trade of the EU with the Eastern European countries in transition has gained increasing importance during the 1990s. However, most expressed increases from 1990 to 2000 for land use associated with exports of the EC/EU can be located in Argentina, India, Indonesia, Malaysia and Morocco. So, especially the newly industrializing economies in Asia have increasingly required agricultural land by imports from the EU.

In addition to the agricultural land available in the EC/EU (comprising arable land, permanent crops, permanent pastures), imports of agricultural commodities required about one third of additional agricultural land in foreign countries. From 1990 to 2000, domestic consumption of agricultural goods in the EC/EU required between 17% and 24% more agricultural land than is available on the territory of the EC/EU, with the lower ratios of 17-18% found for the EU-15 from 1997 to 2000.
The EC/EU required from 1990 to 2000 between 0.49 and 0.44 hectares agricultural land per capita for the domestic consumption of agricultural goods, with lower and rather declining values for the EU-15 from 1995 to 2000. Compared with the global per capita availability of all agricultural land, the EC/EU had required constantly only 52% to 53% of the global average. However, this calculation includes also permanent pastures which in DC are often at least semi-natural grasslands, not comparable to permanent pastures in Europe. If only arable land and permanent crops are taken as basis for comparison - which reflects the comparability of the area categories in terms of intensity of cultivation - , the land requirements of the EC/EU per capita range even slightly above the global average availability of arable and permanent crops land. In this case, the EU would consume agricultural land close to the global average per capita in 2000. Projections of the UN, however, expect the global availability of arable land to decrease to 0.17 ha per capita in 2025. The FAO projects that in the next 30 years developing countries will need an additional 120 million ha for crops. This equals about 4.7 times the area that the EU requires currently by net imports of agricultural goods. Considering that there are limits to the further increase of hectare productivity, this would mean that the EU would have to reduce its global land use for consumption of agricultural goods significantly within the next 20 to 30 years in order to leave other countries enough space for their own consumption of food and feed.

As a result, the seeming excess of agricultural land in the EU and Europe has to be put into perspective. The analysis reveals that global land use of the EU is still on average with global availability with regard to food supply. Growing additional requirements for land use, however, e.g. for biofuels, renewable materials, built-up and conservation area will lead to increasing conflicts. Trade-offs between renewable resource supply and land use should be further studied on the basis of comprehensive material and land use accounts, especially with regard to the further development in the ACC. The economy of Eastern European countries is still based to a significant extent on agricultural production. Whereas a short-term adoption of current EU-15 practices would probably lead to a sharp decline of agricultural land use, however, mid-term to long-term requirements of sustainable resource management in Europe may require a continued use of this area, e.g. for sustainable supply with renewables (food and non-food). Further studies are necessary which consider global land use for the consumption of agricultural commodities in an extended EU, and analyze projections of future land use and resource supply in view of transition of the economies in Eastern Europe and global development trends.
1. Methodology development of MFA towards economic branch accounts

The first part of this study will demonstrate how economy-wide MFA (as referred to in the EUROSTAT Methodological Guide 2001a) is developed towards accounting for the contribution of economic branches to material input and output flows, in particular with regards to the NAMEA methodology and structure, and in order to enhance the use of MFA for providing policy-relevant information to decision makers.

1.1. Allocation of disaggregated material input flows to branches after the NACE rev.1 classification.

Material input flows are allocated to economic branches after the NACE rev.1 classification. These material input flows comprise materials extracted or harvested from the domestic environment (domestic extraction used) as well as imported commodities (together forming the DMI). They further comprise domestic unused materials extractions and indirect material requirements associated with imports (together with DMI forming the TMR). According to the Eurostat guide (Eurostat 2001a) the following additive relations apply for the different material input flow categories and indicators respectively:

\[
\begin{align*}
& + \text{domestic extraction used} \\
& + \text{imports} \\
& = \text{DMI (Direct Material Input)} \\
& + \text{unused domestic extraction} \\
& + \text{indirect flows associated with imports} \\
& = \text{TMR (Total Material Requirement)}
\end{align*}
\]

Allocation of domestic material input flows

The key for attributing domestic material inputs, used and unused, to economic branches is shown in Table A1 in the annex. Only a few economic branches extract or harvest raw materials from the domestic environment, providing these inputs to the economy for further processing or consumption. The following tables 1 and 2 present the allocated domestic material inputs (used and unused) for Germany for the years 1991 to 2000.
Table 1: Domestic extraction used for Germany 1991 to 2000 allocated to economic branches (NACE 2-digits)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>01 Agriculture, hunting and related service activities</td>
<td>204,082</td>
<td>198,076</td>
<td>213,459</td>
<td>192,039</td>
<td>197,793</td>
<td>209,910</td>
<td>210,745</td>
<td>211,321</td>
<td>209,392</td>
<td>213,176</td>
</tr>
<tr>
<td>02 Forestry, logging and related service activities</td>
<td>23,313</td>
<td>20,590</td>
<td>20,553</td>
<td>25,420</td>
<td>28,987</td>
<td>27,281</td>
<td>26,057</td>
<td>28,857</td>
<td>27,851</td>
<td>39,432</td>
</tr>
<tr>
<td>05 Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing</td>
<td>300</td>
<td>311</td>
<td>303</td>
<td>264</td>
<td>296</td>
<td>295</td>
<td>302</td>
<td>317</td>
<td>297</td>
<td>259</td>
</tr>
<tr>
<td>10 Mining of coal and lignite; extraction of peat</td>
<td>346,509</td>
<td>309,266</td>
<td>281,030</td>
<td>259,822</td>
<td>246,669</td>
<td>235,729</td>
<td>223,610</td>
<td>207,326</td>
<td>201,152</td>
<td>201,622</td>
</tr>
<tr>
<td>11 Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying</td>
<td>17,199</td>
<td>17,225</td>
<td>16,946</td>
<td>17,369</td>
<td>17,918</td>
<td>18,947</td>
<td>18,702</td>
<td>18,424</td>
<td>19,227</td>
<td>18,780</td>
</tr>
<tr>
<td>12 Mining of uranium and thorium ores</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13 Mining of metal ores</td>
<td>404</td>
<td>181</td>
<td>146</td>
<td>146</td>
<td>69</td>
<td>104</td>
<td>201</td>
<td>605</td>
<td>615</td>
<td>462</td>
</tr>
<tr>
<td>14 Other mining and quarrying</td>
<td>727,642</td>
<td>776,187</td>
<td>831,014</td>
<td>932,018</td>
<td>859,470</td>
<td>813,578</td>
<td>795,676</td>
<td>767,675</td>
<td>838,579</td>
<td>808,180</td>
</tr>
<tr>
<td>(01-99) All production activities</td>
<td>1,319,455</td>
<td>1,320,836</td>
<td>1,363,452</td>
<td>1,427,078</td>
<td>1,351,190</td>
<td>1,305,845</td>
<td>1,281,293</td>
<td>1,254,424</td>
<td>1,297,113</td>
<td>1,281,909</td>
</tr>
</tbody>
</table>

In Germany, NACE code 14 ‘Other Mining and Quarrying’ reveals to be the most important extracting economic activity in quantitative terms. Some 800 million tonnes of mainly sand and gravel are domestically extracted by this branch. Extraction of hard coal and lignite is another important domestic material input flow in Germany (NACE code 10), though with decreasing trend. Harvest of biomass by the agriculture sector is another constantly high domestic material input with some 200 million tonnes. Although the German economy generates high value added from metal processing, the domestic extraction of metal ores is almost neglectable.

Table 2: Unused domestic extraction for Germany 1991 to 2000 allocated to economic branches (NACE 2-digits)

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Agriculture, hunting and related service activities</td>
<td>151,353</td>
<td>146,993</td>
<td>152,710</td>
<td>149,003</td>
<td>151,995</td>
<td>156,591</td>
<td>156,917</td>
<td>154,065</td>
<td>154,488</td>
<td></td>
</tr>
<tr>
<td>02 Forestry, logging and related service activities</td>
<td>10,561</td>
<td>9,328</td>
<td>9,311</td>
<td>11,516</td>
<td>13,132</td>
<td>12,359</td>
<td>12,710</td>
<td>13,073</td>
<td>12,617</td>
<td>17,865</td>
</tr>
<tr>
<td>05 Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing</td>
<td>85</td>
<td>89</td>
<td>86</td>
<td>73</td>
<td>80</td>
<td>84</td>
<td>86</td>
<td>92</td>
<td>85</td>
<td>72</td>
</tr>
<tr>
<td>10 Mining of coal and lignite; extraction of peat</td>
<td>2,436,037</td>
<td>2,098,404</td>
<td>2,189,427</td>
<td>2,015,524</td>
<td>1,891,034</td>
<td>1,794,106</td>
<td>1,685,668</td>
<td>1,648,542</td>
<td>1,676,613</td>
<td>1,643,981</td>
</tr>
<tr>
<td>11 Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying</td>
<td>654</td>
<td>638</td>
<td>617</td>
<td>616</td>
<td>638</td>
<td>656</td>
<td>651</td>
<td>645</td>
<td>654</td>
<td>658</td>
</tr>
<tr>
<td>13 Mining of metal ores</td>
<td>463</td>
<td>117</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14 Other mining and quarrying</td>
<td>154,191</td>
<td>163,827</td>
<td>176,368</td>
<td>199,107</td>
<td>187,084</td>
<td>178,856</td>
<td>179,856</td>
<td>177,737</td>
<td>187,802</td>
<td>183,851</td>
</tr>
<tr>
<td>45 Construction</td>
<td>300,233</td>
<td>293,300</td>
<td>300,233</td>
<td>342,616</td>
<td>355,369</td>
<td>395,826</td>
<td>392,853</td>
<td>287,833</td>
<td>287,206</td>
<td>280,239</td>
</tr>
</tbody>
</table>

The unused domestic extraction (Table 2) obviously relates closely to the previous discussed used domestic extraction. Unused means that this material is extracted at the same time as the used material. It is, however, not further processed in the economic production system but shifted aside in the form of e.g. mining waste, tailings, biotic residuals from harvest etc. The unused domestic extraction activated by the construction sector (NACE code 45) is an exception. It constitutes excavation and dredging by the construction sector and is often transformed to construction waste. The majority of the remaining branches have unused domestic extractions lower than the used ones. The coal and lignite mining (NACE code 10) forms an exception. Here, the unused material fraction is 7 to 8 times higher than the used
material. With other word, per tonne useable coal and lignite about 7 to 8 tons of mining overburden and waste is generated.

**Allocation of imports and indirect flows associated with imports**

The attribution of material input flows associated to imported commodities to receiving economic branches requires a two-step-approach.

1. Imported commodities in physical units, as available from the Eurostat Comext foreign trade statistics, are classified according to the combined nomenclature (CN). In a first step, they have been aggregated to the 60 product groups according to CPA 2-digits classification which is fully compatible with the 2-digits NACE Rev.1 classification for economic activities. This aggregation step is documented in Table A2 in the annex.

2. Yet, the vector of 60 imported product groups does not provide the information which sector actually receives the respective import goods and associated material inputs. Therefore, this vector has to be allocated to the receiving economic branches, and, in addition, to the categories of final demand. The latter is necessary due to the fact that some imported commodities are directly absorbed by final demand (e.g. consumption of private households). This allocation of imported commodities (and associated material inputs) to the receiving economic branches and categories of final demand has been performed by using monetary and physical import tables. For 1995, a physical import table is available (Federal Statistical Office 2002a) which was used to calculate commodity-specific weight/value-coefficients by relating it to the monetary import table in constant prices. These specific weight/value-coefficients were used to compile for the years 1991-2000 ‘artificial’ physical import matrices using the yearly available monetary import tables (Federal Statistical Office 2002b). As a result, a 1991-2000 time series of physical import matrices was obtained and for each table physical output-coefficient were calculated. The latter were used to allocate each of the 60 import product groups to the receiving economic branches and categories of final demand.

As a result, Tables 3 and 4 show imports and associated indirect flows by receiving economic branch (NACE rev.1 2-digits) and/or category of final demand for Germany 1991 to 2000.
<table>
<thead>
<tr>
<th>Economic Branches</th>
<th>NACE Rev. 1 (2-digit) codes</th>
<th>Categories of Final Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Agriculture, hunting and related service activities</td>
<td>01.01 Agriculture</td>
<td>01.02 Hunting</td>
</tr>
<tr>
<td>02 Forestry, fishing and related service activities</td>
<td>02.01 Forestry</td>
<td>02.02 Fishing</td>
</tr>
<tr>
<td>03 Fishing, operation of fish-harvesting and fish-farming vessels</td>
<td>03.01 Fishing</td>
<td>03.02 Operation of fish-harvesting and fish-farming vessels</td>
</tr>
<tr>
<td>04 Mining and quarrying</td>
<td>04.01 Mining of coal and lignite</td>
<td>04.02 Quarrying of building materials</td>
</tr>
<tr>
<td>05 Extraction of crude petroleum and natural gas</td>
<td>05.01 Extraction of crude petroleum</td>
<td>05.02 Extraction of natural gas</td>
</tr>
<tr>
<td>06 Manufacture of coke, refined petroleum products and nuclear fuel</td>
<td>06.01 Manufacture of coke, refined petroleum products</td>
<td>06.02 Nuclear fuel production</td>
</tr>
<tr>
<td>07 Manufacture of chemicals and chemical products</td>
<td>07.01 Manufacture of medicinal and pharmaceutical products</td>
<td>07.02 Manufacture of basic chemicals</td>
</tr>
<tr>
<td>08 Manufacture of plastic and rubber products</td>
<td>08.01 Manufacture of rubber products</td>
<td>08.02 Manufacture of plastic products</td>
</tr>
<tr>
<td>09 Manufacture of metal products</td>
<td>09.01 Manufacture of basic metals</td>
<td>09.02 Manufacture of fabricated metal products, except machinery and equipment</td>
</tr>
<tr>
<td>10 Manufacture of mechanical equipment, n.e.c.</td>
<td>10.01 Manufacture of machinery and equipment</td>
<td>10.02 Manufacture of specialized machinery and equipment</td>
</tr>
<tr>
<td>11 Manufacture of transport equipment, n.e.c.</td>
<td>11.01 Manufacture of transport and heavy machinery</td>
<td>11.02 Manufacture of transport and light machinery</td>
</tr>
<tr>
<td>12 Manufacture of electronic and optical instruments, watches and clocks</td>
<td>12.01 Manufacture of precision measuring instruments</td>
<td>12.02 Manufacture of medical and precision optical instruments, watches and clocks</td>
</tr>
<tr>
<td>13 Manufacture of motor vehicles, tractors and semi-trailers</td>
<td>13.01 Manufacture of motor vehicles</td>
<td>13.02 Manufacture of tractors and semi-trailers</td>
</tr>
<tr>
<td>14 Manufacture of other transport equipment</td>
<td>14.01 Manufacture of other transport equipment</td>
<td>14.02 Manufacture of non-electrical machinery</td>
</tr>
<tr>
<td>15 Manufacture of furniture; manufacturing n.e.c.</td>
<td>15.01 Manufacture of furniture</td>
<td>15.02 Manufacture of other manufacturing n.e.c.</td>
</tr>
<tr>
<td>16 Electrical and optical equipment; sound recording and reproducing equipment; motion picture and television equipment; scientific instruments and apparatus</td>
<td>16.01 Manufacture of electrical and optical equipment</td>
<td>16.02 Manufacture of sound recording and reproducing equipment</td>
</tr>
<tr>
<td>17 Manufacturing of wearing apparel; dressing and dyeing of fur</td>
<td>17.01 Manufacture of wearing apparel</td>
<td>17.02 Manufacturing of wearing apparel, dressing and dyeing of fur</td>
</tr>
<tr>
<td>18 Tanning and dressing of leather; manufacture of footwear</td>
<td>18.01 Tanning and dressing of leather</td>
<td>18.02 Manufacture of footwear</td>
</tr>
<tr>
<td>19 Other service activities</td>
<td>19.01 Activities auxiliary to financial intermediation</td>
<td>19.02 Activities auxiliary to financial intermediation</td>
</tr>
</tbody>
</table>
| 20 Wholesale and retail trade; repair of motor vehicles and motorcycles; retail sale of automotive fuel | 20.01 Wholesale trade and commission trade | 20.02 Retail trade, except of motor vehicles and motorcycles;
| 21 Cafe-bar and catering activities | 21.01 Cafe-bar and catering activities | repair of personal and household goods; |
| 22 Hotels and restaurants | 22.01 Hotels and restaurants | retail sale of automotive fuel; |
| 23 Leisure, cultural and sporting activities | 23.01 Leisure, cultural and sporting activities | activities of membership organizations n.e.c.; |
| 24 Protective service activities | 24.01 Protective service activities | health and social work; |
| 25 Financial intermediation | 25.01 Financial intermediation | real estate activities; |
| 26 Insurance and pension funding | 26.01 Insurance and pension funding | activities auxiliary to financial intermediation; |
| 27 Other service activities | 27.01 Other service activities | activities auxiliary to financial intermediation; |
| 28 Wholesale and retail trade; repair of motor vehicles and motorcycles; retail sale of automotive fuel | 28.01 Wholesale trade and commission trade | repair of personal and household goods; |
| 29 Hotels and restaurants | 29.01 Hotels and restaurants | retail sale of automotive fuel; |
| 30 Leisure, cultural and sporting activities | 30.01 Leisure, cultural and sporting activities | activities of membership organizations n.e.c.; |
| 31 Financial intermediation | 31.01 Financial intermediation | health and social work; |
| 32 Insurance and pension funding | 32.01 Insurance and pension funding | real estate activities; |
| 33 Other service activities | 33.01 Other service activities | activities auxiliary to financial intermediation; |
| 34 Wholesale and retail trade; repair of motor vehicles and motorcycles; retail sale of automotive fuel | 34.01 Wholesale trade and commission trade | repair of personal and household goods; |
| 35 Cafes, bars and restaurants | 35.01 Cafes, bars and restaurants | retail sale of automotive fuel; |
| 36 Protective service activities | 36.01 Protective service activities | activities of membership organizations n.e.c.; |
| 37 Health and social work | 37.01 Health and social work | activities auxiliary to financial intermediation; |
| 38Real estate activities | 38.01 Real estate activities | activities auxiliary to financial intermediation; |
| 39 Activities auxiliary to financial intermediation | 39.01 Activities auxiliary to financial intermediation | activities auxiliary to financial intermediation; |
| 40 Financial intermediation | 40.01 Financial intermediation | activities auxiliary to financial intermediation; |
| 41 Insurance and pension funding | 41.01 Insurance and pension funding | activities auxiliary to financial intermediation; |
| 42 Other service activities | 42.01 Other service activities | activities auxiliary to financial intermediation; |
| 43 Wholesale and retail trade; repair of motor vehicles and motorcycles; retail sale of automotive fuel | 43.01 Wholesale trade and commission trade | repair of personal and household goods; |
| 44 Cafes, bars and restaurants | 44.01 Cafes, bars and restaurants | retail sale of automotive fuel; |
| 45 Protective service activities | 45.01 Protective service activities | activities of membership organizations n.e.c.; |
| 46 Health and social work | 46.01 Health and social work | activities auxiliary to financial intermediation; |
| 47Real estate activities | 47.01 Real estate activities | activities auxiliary to financial intermediation; |
| 48 Activities auxiliary to financial intermediation | 48.01 Activities auxiliary to financial intermediation | activities auxiliary to financial intermediation; |
| 49 Financial intermediation | 49.01 Financial intermediation | activities auxiliary to financial intermediation; |
| 50 Insurance and pension funding | 50.01 Insurance and pension funding | activities auxiliary to financial intermediation; |
| 51 Other service activities | 51.01 Other service activities | activities auxiliary to financial intermediation; |
| 52 Wholesale and retail trade; repair of motor vehicles and motorcycles; retail sale of automotive fuel | 52.01 Wholesale trade and commission trade | repair of personal and household goods; |
| 53 Cafes, bars and restaurants | 53.01 Cafes, bars and restaurants | retail sale of automotive fuel; |
| 54 Protective service activities | 54.01 Protective service activities | activities of membership organizations n.e.c.; |
| 55 Health and social work | 55.01 Health and social work | activities auxiliary to financial intermediation; |
| 56Real estate activities | 56.01 Real estate activities | activities auxiliary to financial intermediation; |
| 57 Activities auxiliary to financial intermediation | 57.01 Activities auxiliary to financial intermediation | activities auxiliary to financial intermediation; |
| 58 Financial intermediation | 58.01 Financial intermediation | activities auxiliary to financial intermediation; |
| 59 Insurance and pension funding | 59.01 Insurance and pension funding | activities auxiliary to financial intermediation; |
| 60 Other service activities | 60.01 Other service activities | activities auxiliary to financial intermediation; |

Important economic branches importing significant amounts of materials mainly in the form of raw materials and semi-manufactured goods are the basic metals industry (NACE code 27), chemical industry (24), the energy transformation sector (40), and the refining industries (23). Final consumption of private households is the most important category of final demand. Significant amounts of imported commodities are going directly into this sector.
### Table 4: Indirect flows associated to imports allocated to receiving economic branches (NACE 2-digits)

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Manufacture of basic metals (01-99)</td>
<td>132.153</td>
<td>130.052</td>
<td>124.140</td>
<td>115.100</td>
<td>112.010</td>
<td>107.503</td>
<td>106.110</td>
<td>105.000</td>
<td>103.990</td>
<td>103.990</td>
</tr>
<tr>
<td>Manufacture of tobacco products</td>
<td>996</td>
<td>987</td>
<td>987</td>
<td>956</td>
<td>1.554</td>
<td>1.292</td>
<td>1.066</td>
<td>1.062</td>
<td>1.131</td>
<td>1.106</td>
</tr>
<tr>
<td>Manufacture of wearing apparel, dressing and dyeing</td>
<td>1.414</td>
<td>1.424</td>
<td>1.401</td>
<td>1.233</td>
<td>1.396</td>
<td>1.413</td>
<td>1.400</td>
<td>1.415</td>
<td>1.411</td>
<td>1.111</td>
</tr>
<tr>
<td>Fishing and hunting</td>
<td>262</td>
<td>288</td>
<td>285</td>
<td>341</td>
<td>246</td>
<td>218</td>
<td>269</td>
<td>462</td>
<td>381</td>
<td>241</td>
</tr>
<tr>
<td>Manufacture of coke, refined petroleum products and nuclear fuel</td>
<td>41.525</td>
<td>38.930</td>
<td>34.154</td>
<td>39.350</td>
<td>36.014</td>
<td>40.148</td>
<td>42.105</td>
<td>43.711</td>
<td>41.094</td>
<td></td>
</tr>
<tr>
<td>Manufacture of chemicals and chemical products</td>
<td>48.983</td>
<td>49.039</td>
<td>41.186</td>
<td>44.844</td>
<td>43.420</td>
<td>39.359</td>
<td>38.795</td>
<td>39.789</td>
<td>38.988</td>
<td>46.881</td>
</tr>
<tr>
<td>Construction</td>
<td>90.897</td>
<td>91.015</td>
<td>69.063</td>
<td>81.381</td>
<td>72.875</td>
<td>74.893</td>
<td>76.003</td>
<td>71.305</td>
<td>75.547</td>
<td></td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>1.178</td>
<td>1.107</td>
<td>764</td>
<td>861</td>
<td>841</td>
<td>802</td>
<td>892</td>
<td>942</td>
<td>819</td>
<td>932</td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>41.401</td>
<td>40.610</td>
<td>41.355</td>
<td>38.673</td>
<td>36.860</td>
<td>40.254</td>
<td>42.112</td>
<td>50.971</td>
<td>54.283</td>
<td></td>
</tr>
<tr>
<td>Wholesale trade and commission business</td>
<td>6.494</td>
<td>7.096</td>
<td>5.980</td>
<td>5.179</td>
<td>5.382</td>
<td>5.562</td>
<td>5.110</td>
<td>5.717</td>
<td>5.467</td>
<td></td>
</tr>
<tr>
<td>Manufacture of coke, refined petroleum products and nuclear fuel</td>
<td>133.333</td>
<td>143.988</td>
<td>126.163</td>
<td>130.241</td>
<td>125.042</td>
<td>119.033</td>
<td>121.640</td>
<td>126.453</td>
<td>127.017</td>
<td></td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>25.929</td>
<td>27.554</td>
<td>36.286</td>
<td>49.209</td>
<td>45.786</td>
<td>43.550</td>
<td>41.953</td>
<td>39.531</td>
<td>39.075</td>
<td></td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>5.609</td>
<td>5.238</td>
<td>4.416</td>
<td>5.015</td>
<td>4.690</td>
<td>4.436</td>
<td>4.761</td>
<td>4.742</td>
<td>5.115</td>
<td>5.017</td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>5.609</td>
<td>5.238</td>
<td>4.416</td>
<td>5.015</td>
<td>4.690</td>
<td>4.436</td>
<td>4.761</td>
<td>4.742</td>
<td>5.115</td>
<td>5.017</td>
</tr>
</tbody>
</table>

The indirect flows associated with imports – also termed “ecological rucksacks” of imported goods – represent primary resource requirements in the exporting countries and the rest of the world respectively which were activated to produce the respective import commodity.

Economic branches importing commodities with particular high “rucksacks” are basic metals.

---

**Economic branches**:...
industries (NACE code 27), the metal fabricating industries (28) but also increasingly the car industry (34). Also the food industries import goods with high “ecological rucksacks” as do private households through the direct demand of imported goods.

**Allocation of indicators (DMI, TMR)**

Finally, the single material input flow categories allocated to economic branches and categories as shown in tables 1 to 4 can be aggregated to indicators, such as the DMI and/or TMR. Tables 5 and 6 present the DMI and TMR, respectively, allocated to economic branches and categories of final demand for Germany.

For DMI, the mining and quarrying industry (NACE code 14) shows the highest dominance; as mentioned earlier, this is due to high amounts of domestic extracted construction minerals such as sand and gravel. The coal and lignite mining industry (10) reveals still significant high amounts of DMI, though with decreasing trends. Agriculture is another important branch with an almost constant DMI.

For TMR, the coal and lignite mining industry is the most important economic branch. Here, the “ecological rucksacks” of imported commodities into the sector play an important role. The same apply for the basic metal industry (NACE code 27).

The following table 7 presents as supplementary information of relevance the total numbers and shares of DMI and TMR for domestic and foreign materials. This is to indicate the economy’s dependency on foreign resources associated with potential shifts of environmental burden to foreign countries and potential risks of security for supply (see also chapter 3.2). For both indicators, DMI and TMR, a declining trend for domestic material input flows can be observed. On the other hand, foreign shares are increasing, indicating a growing dependency on natural resources outside of Germany.


Table 5: DMI allocated to economic branches and categories of final demand, Germany 1991-2000

<table>
<thead>
<tr>
<th>Year</th>
<th>Agriculture, hunting and related service activities</th>
<th>Forestry, logging and related service activities</th>
<th>Fishing, processing of fish and fish farms; sea service activities incident to fishing</th>
<th>Mining of coal and lignite; extraction of peat</th>
<th>Extraction of crude petroleum and natural gas; service activities incident to oil and gas extraction</th>
<th>Manufacturing of food products and beverages</th>
<th>Manufacturing of textile products</th>
<th>All final consumption activities</th>
</tr>
</thead>
</table>

Note: The data are in millions of 1990 DM and are rounded to the nearest million.
Table 6: TMR allocated to economic branches and categories of final demand, Germany 1991-2000

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacture of food products and beverages</td>
<td>136.892</td>
<td>142.407</td>
<td>127.634</td>
<td>117.687</td>
<td>128.954</td>
<td>133.369</td>
<td>138.574</td>
<td>146.941</td>
<td>133.257</td>
<td>133.109</td>
</tr>
<tr>
<td>Manufacture of metal products and components</td>
<td>57.804</td>
<td>55.670</td>
<td>56.841</td>
<td>56.120</td>
<td>39.810</td>
<td>41.837</td>
<td>50.318</td>
<td>47.829</td>
<td>52.143</td>
<td>51.319</td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>46.258</td>
<td>46.812</td>
<td>45.527</td>
<td>51.015</td>
<td>43.827</td>
<td>45.075</td>
<td>48.701</td>
<td>55.946</td>
<td>58.054</td>
<td>59.622</td>
</tr>
<tr>
<td>Manufacture of textiles</td>
<td>6.189</td>
<td>6.056</td>
<td>5.579</td>
<td>5.675</td>
<td>5.675</td>
<td>5.563</td>
<td>5.609</td>
<td>5.609</td>
<td>5.514</td>
<td>5.383</td>
</tr>
<tr>
<td>Manufacture of paper and of products of paper and cork</td>
<td>875</td>
<td>921</td>
<td>881</td>
<td>1.026</td>
<td>967</td>
<td>915</td>
<td>891</td>
<td>929</td>
<td>1.030</td>
<td>1.229</td>
</tr>
<tr>
<td>Manufacture of rubber products and plastics</td>
<td>161</td>
<td>167</td>
<td>183</td>
<td>202</td>
<td>91</td>
<td>191</td>
<td>172</td>
<td>174</td>
<td>172</td>
<td>144</td>
</tr>
<tr>
<td>Manufacture of precision and optical instruments</td>
<td>464</td>
<td>423</td>
<td>517</td>
<td>550</td>
<td>542</td>
<td>476</td>
<td>515</td>
<td>489</td>
<td>565</td>
<td>580</td>
</tr>
<tr>
<td>Financial intermediation, except insurance and pensions</td>
<td>3.234</td>
<td>3.065</td>
<td>2.869</td>
<td>2.789</td>
<td>2.789</td>
<td>2.789</td>
<td>2.789</td>
<td>2.789</td>
<td>2.789</td>
<td>2.789</td>
</tr>
<tr>
<td>Renting of machinery and equipment</td>
<td>5.659</td>
<td>5.713</td>
<td>5.508</td>
<td>5.633</td>
<td>5.633</td>
<td>5.633</td>
<td>5.633</td>
<td>5.633</td>
<td>5.633</td>
<td>5.633</td>
</tr>
<tr>
<td>Transportation and storage activities</td>
<td>74.911</td>
<td>83.153</td>
<td>73.825</td>
<td>80.607</td>
<td>73.250</td>
<td>63.300</td>
<td>72.435</td>
<td>80.175</td>
<td>85.143</td>
<td>88.292</td>
</tr>
</tbody>
</table>
|」「「

Table 7: Domestic versus foreign shares DMI and TMR, Germany 1991-2000

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic Share</th>
<th>Foreign Share</th>
<th>Total Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>1,749,010</td>
<td>1,722,505</td>
<td>3,471,515</td>
</tr>
<tr>
<td>1992</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1993</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1994</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1995</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1996</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1997</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1998</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1999</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>2000</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
</tbody>
</table>

Foreign Share from Domestic Consumption (%): 75% in 1991, 75% in 1992, 75% in 1993, 75% in 1994, 75% in 1995, 75% in 1996, 75% in 1997, 75% in 1998, 75% in 1999, 75% in 2000

Table 8: Domestic versus foreign shares DMI and TMR, Germany 1991-2000

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic Share</th>
<th>Foreign Share</th>
<th>Total Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>1,749,010</td>
<td>1,722,505</td>
<td>3,471,515</td>
</tr>
<tr>
<td>1992</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1993</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1994</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1995</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1996</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1997</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1998</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>1999</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
<tr>
<td>2000</td>
<td>1,783,974</td>
<td>1,828,670</td>
<td>3,612,644</td>
</tr>
</tbody>
</table>

Foreign Share from Domestic Consumption (%): 75% in 1991, 75% in 1992, 75% in 1993, 75% in 1994, 75% in 1995, 75% in 1996, 75% in 1997, 75% in 1998, 75% in 1999, 75% in 2000
It was also examined in this part of the study down to which level economic branches should be disaggregated. This depends on the relative contribution of sub-sectors to the total of major material flow categories. For example, precious metals represent a rather small part of the used material input (DMI) of all metals. However, because of extremely high ratios of unused to used extractions, they contribute significantly to the Total Material Requirement (TMR) of economies. This can be illustrated for the basic metal industry by comparing the respective allocated DMI (Table 5) with the direct allocated TMR (Table 6). In order to provide this information the respective economic branch for precious metals manufacturing could be differentiated from the (total) metals manufacturing branch. Such kind of selection of branches was done for the entire set of material input data based on the expertise of the Wuppertal Institute in economy-wide MFA, especially for the EU (Bringezu and Schütz 2001a) and for the United Kingdom (Bringezu and Schütz 2001b, DEFRA 2002, Sheerin 2002). In general, the allocations provide the basis for evaluation of those branches that will be challenged most by potential reductions of material inputs, e.g. due to policy measures.

The direct allocations of material inputs as presented in this section may form the starting point for further input-output based analysis of e.g. the re-attribution of material inputs to final demanded product groups (Moll et al, 2003, work in progress). This kind of analysis may be a future task in economy-wide MFA to further increase the use for providing policy-relevant information.

1.2. Breakdown by major material categories

Material input flows accounted for as described in section 1.1 can be further disaggregated into major groups with respect to material types. According to Eurostat MFA Guide (Eurostat 2001), the material input flows can be classified into the following broad material categories:

- **Fossil Fuels**
- **Minerals**
  - metal ores
  - industrial minerals
  - construction minerals
- **Biomass**

On a first level of disaggregation, three main material categories are distinguished: fossil fuels, minerals, and biomass. Since minerals constitute quantitatively and qualitatively a very broad category, it is further broken down into metal ores, industrial minerals, and construction minerals. As a result, 5 major material categories are derived.
For each of the 5 material categories, tables for the year 2000 are given in the following (Tables 9 to 13). In the columns, the summary tables show the four single flow categories (domestic extraction used, unused domestic extraction, imports, indirect flows associated with imports) and the derived aggregate indicators DMI, TMI, and TMR. Thereby, they reveal several kind of information (see Table 8).

For example, for each material category material inputs of foreign origin can be differentiated from domestically extracted/harvested materials, indicating the dependence on foreign resources. Further, the relative environmental burden can be expressed by the volumes of unused or indirect flows as compared with direct material inputs (DMI).

By distinguishing the material inputs by material categories, non-renewable materials are differentiated from renewable materials. The summary table on biomass has to be regarded as representing the renewable fraction. Whereas, the summary tables of the remaining material categories represent non-renewables indicating the dependence of economic branches on materials that cannot be reproduced by nature.

Before the five tables by material categories and by economic branches are shown, a summary table for the total German economy is given (Table 8).

**Table 8: Material input flows by major material categories**

<table>
<thead>
<tr>
<th>Material Input Flows by major material categories Germany 2000</th>
<th>Excavation and dredging</th>
<th>Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow categories</td>
<td>Domestic extraction used</td>
<td>Unused domestic extraction</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Total</td>
<td>1,281,909</td>
<td>1,879,417</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>220,402</td>
<td>1,644,639</td>
</tr>
<tr>
<td>Metal ores</td>
<td>462</td>
<td>0</td>
</tr>
<tr>
<td>Industrial minerals</td>
<td>81,784</td>
<td>40,254</td>
</tr>
<tr>
<td>Construction minerals</td>
<td>726,396</td>
<td>143,597</td>
</tr>
<tr>
<td>Biomass</td>
<td>252,966</td>
<td>50,928</td>
</tr>
<tr>
<td>Total</td>
<td>1,281,909</td>
<td>1,879,417</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>17</td>
<td>88</td>
</tr>
<tr>
<td>Metal ores</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Industrial minerals</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Construction minerals</td>
<td>57</td>
<td>8</td>
</tr>
<tr>
<td>Biomass</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>9</td>
<td>69</td>
</tr>
<tr>
<td>Metal ores</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Industrial minerals</td>
<td>64</td>
<td>26</td>
</tr>
<tr>
<td>Construction minerals</td>
<td>79</td>
<td>16</td>
</tr>
<tr>
<td>Biomass</td>
<td>43</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>35</td>
</tr>
</tbody>
</table>

The first part of Table 8 provides the absolute amounts of the several material categories by flow categories. The second part presents how much the single material categories contribute to the respective flow category. For instance, domestic extraction used is dominated by construction minerals, whereas unused domestic extraction is dominated by fossil fuels.
Indirect flows associated to imports are highly dominated by metals. The third part of Table 8 shows the contribution of flow categories to TMR by material categories. For instance, the TMR of metals is dominated by indirect flows associated to imports, whereas the TMR of biomass is dominated by domestic extraction used.

The following five tables are showing for each material category a breakdown by economic branches.

Table 9: TMR – Fossil Fuels, Germany 2000

In 2000, the TMR of fossil fuels amounted to some 2374 million tonnes in Germany. Thereof, about two thirds were unused, of which the domestic unused fraction is clearly dominating.
About 41% of the TMR of fossil fuels was from sources outside Germany. With more than 1.9 billion tonnes, the German mining industry is requiring the majority of TMR of fossil fuels. Other economic branches with considerable high appropriations of TMR of fossil fuels are the refinery industries (NACE code 23), chemicals industry (24), and the electricity sector (40). The direct final demand of imported goods by private households also considerably contributes to the TMR of fossil fuels.

Table 10: TMR – metal ores, Germany 2000

<table>
<thead>
<tr>
<th>NACE Code</th>
<th>Branches</th>
<th>direct material inputs by economic branches</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>Agriculture, hunting and related service activities</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Water transport and related service activities</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Air transport and related service activities</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Other transport and related services</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Wholesale and retail trade</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Hotels and restaurants</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Financial intermediation</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Insurance and pension funding</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Other human and social service activities</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NACE Code</th>
<th>Branches</th>
<th>Material Flows - metals</th>
<th>Germany 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Agriculture, hunting and related service activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>01</td>
<td>Wholesale and retail trade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Hotels and restaurants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Financial intermediation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Insurance and pension funding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>Other human and social service activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With some 1260 million tonnes, the TMR of metals also contributes significantly to the total TMR of Germany. The majority of 69% of TMR metals is due to the flow category of indirect flows associated with imports.
The basic metal industries (NACE code 27) constitute the dominant economic branch with some 516 million tonnes. The manufacturing of fabricated metal products (28) and the car industries (34) are further important economic activities. Also the several categories of final demand constitute important “users” of TMR of metals (via direct use of imported goods). It is interesting to observe that a considerable amount of imported goods, containing high amounts of “ecological rucksacks” in form of TMR of metals, is re-exported immediately.

Table 11: TMR – industrial minerals, Germany 2000

<table>
<thead>
<tr>
<th>Nace Code</th>
<th>Branches</th>
<th>direct material inputs by economic branches</th>
<th>Germany 2000</th>
</tr>
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<tbody>
<tr>
<td>10</td>
<td>Agriculture, hunting and related service activities</td>
<td>448</td>
<td>898</td>
</tr>
<tr>
<td>11</td>
<td>Forestry, leather and related service activities</td>
<td>448</td>
<td>898</td>
</tr>
<tr>
<td>12</td>
<td>Fishing, hunting, trapping and related service activities</td>
<td>448</td>
<td>898</td>
</tr>
<tr>
<td>13</td>
<td>Mining of crude and higher extraction of coal</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>14</td>
<td>Mining of crude and higher extraction of gas</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>Mining of non-metallic minerals (N.B.C.)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>Mining of metallic minerals (N.B.C.)</td>
<td>81 794</td>
<td>40 264</td>
</tr>
<tr>
<td>17</td>
<td>Manufacturing of fabricated metal products, except machinery and equipment</td>
<td>208</td>
<td>201</td>
</tr>
<tr>
<td>18</td>
<td>Manufacturing of metal products</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>19</td>
<td>Manufacturing of machinery and equipment</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>Manufacturing of iron and steel</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>Manufacturing of metal, plastic and rubber products</td>
<td>67</td>
<td>50</td>
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<tr>
<td>22</td>
<td>Manufacturing of wood and of products of wood and cork, except furniture</td>
<td>101</td>
<td>118</td>
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<tr>
<td>23</td>
<td>Manufacturing of paper and paper products</td>
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<td>3</td>
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<tr>
<td>24</td>
<td>Manufacturing of coal, petroleum products and nuclear fuel</td>
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<td>0</td>
</tr>
<tr>
<td>25</td>
<td>Manufacturing of chemicals and chemical products</td>
<td>451</td>
<td>356</td>
</tr>
<tr>
<td>26</td>
<td>Manufacturing of coke, refined petroleum products, except machinery and equipment</td>
<td>2 211</td>
<td>2 576</td>
</tr>
<tr>
<td>27</td>
<td>Manufacturing of rubber and plastic products</td>
<td>117</td>
<td>53</td>
</tr>
<tr>
<td>28</td>
<td>Manufacturing of leather and leather products</td>
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<td>0</td>
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<tr>
<td>29</td>
<td>Manufacturing of machinery and equipment</td>
<td>27</td>
<td>26</td>
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<tr>
<td>30</td>
<td>Manufacturing of electrical machinery and apparatus</td>
<td>86</td>
<td>86</td>
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<td>31</td>
<td>Manufacturing of transport equipment</td>
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<td>100</td>
</tr>
<tr>
<td>32</td>
<td>Manufacturing of electrical machines and apparatus</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>33</td>
<td>Manufacturing of metal, plastic and rubber products</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
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<td>Manufacturing of iron and steel</td>
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<tr>
<td>35</td>
<td>Manufacturing of iron and steel</td>
<td>27</td>
<td>19</td>
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<tr>
<td>36</td>
<td>Manufacturing of non-ferrous metals</td>
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<td>0</td>
</tr>
<tr>
<td>37</td>
<td>Manufacture of building materials and appliances</td>
<td>2 999</td>
<td>2 999</td>
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<tr>
<td>38</td>
<td>Manufacture of machinery and equipment</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>39</td>
<td>Manufacture of footwear and leather</td>
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<td>0</td>
</tr>
<tr>
<td>40</td>
<td>Manufacture of metal, plastic and rubber products</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>41</td>
<td>Manufacture of food products and beverages</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>42</td>
<td>Manufacture of paper and paper products</td>
<td>18</td>
<td>18</td>
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<tr>
<td>43</td>
<td>Manufacture of chemicals and chemical products</td>
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<td>44</td>
<td>Manufacture of coke, petroleum products and nuclear fuel</td>
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</tr>
<tr>
<td>45</td>
<td>Manufacture of electric machinery and apparatus</td>
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<td>1</td>
</tr>
<tr>
<td>46</td>
<td>Manufacture of machinery and equipment</td>
<td>1</td>
<td>1</td>
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<tr>
<td>47</td>
<td>Manufacture of metal, plastic and rubber products</td>
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<td>0</td>
</tr>
<tr>
<td>48</td>
<td>Manufacture of machinery and equipment</td>
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</tbody>
</table>

With some 152 million tonnes, the TMR of industrial minerals is not playing a significant role. About three fourth are attributable to the German mining and quarrying industries (NACE code 14).
### Table 12: TMR – construction minerals, Germany 2000

<table>
<thead>
<tr>
<th>Material Flows – construction minerals, direct material inputs by economic branches (Germany 2000)</th>
</tr>
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<tr>
<td><strong>Material Flows</strong></td>
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<td>97</td>
</tr>
<tr>
<td>98</td>
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<tr>
<td>99</td>
</tr>
</tbody>
</table>

TMR of construction, which in total amounted to some 914 million tonnes, is also primarily extracted by the German mining and quarrying industries (NACE code 14). The excavation and dredging by the construction sector is also an important material input flow related to construction minerals.
Table 13: TMR – Biomass, Germany 2000

<table>
<thead>
<tr>
<th>Nace Code Branches</th>
<th>domestic extraction used</th>
<th>unused indirect extraction</th>
<th>imports from associated path imports</th>
<th>DMI</th>
<th>TMI</th>
<th>TMR</th>
<th>unused indirect extraction associated with imports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000 tonnes</td>
<td>1000 tonnes</td>
<td>1000 tonnes</td>
<td>1000 tonnes</td>
<td>1000 tonnes</td>
<td>1000 tonnes</td>
<td>1000 tonnes</td>
</tr>
<tr>
<td>04 Agriculture, hunting and related services</td>
<td>213 114</td>
<td>34 949</td>
<td>565</td>
<td>7 966</td>
<td>260 066</td>
<td>266 666</td>
<td>121 844</td>
</tr>
<tr>
<td>05 Forestry and fishing</td>
<td>213 432</td>
<td>17 943</td>
<td>261</td>
<td>246</td>
<td>39 723</td>
<td>16 580</td>
<td>57 565</td>
</tr>
<tr>
<td>10 Mining of fuels and related services</td>
<td>259</td>
<td>72</td>
<td>10</td>
<td>8</td>
<td>269</td>
<td>341</td>
<td>349</td>
</tr>
<tr>
<td>11 Mining of non-ferrous metals</td>
<td>10</td>
<td>39</td>
<td>10</td>
<td>10</td>
<td>40</td>
<td>49</td>
<td>5</td>
</tr>
<tr>
<td>12 Mining of coal</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13 Mining of salt</td>
<td>40</td>
<td>156</td>
<td>40</td>
<td>40</td>
<td>230</td>
<td>160</td>
<td></td>
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<tr>
<td>14 Manufacture of food products and beverages</td>
<td>17 375</td>
<td>30 260</td>
<td>17 375</td>
<td>17 375</td>
<td>67 015</td>
<td>84 560</td>
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<tr>
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<td>146</td>
<td>146</td>
<td>520</td>
<td>520</td>
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<td>16 Manufacture of chemicals and chemical products</td>
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<td>218</td>
<td>211</td>
<td>211</td>
<td>728</td>
<td>728</td>
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<tr>
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<td>55</td>
<td>55</td>
<td>429</td>
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<td>21 Manufacture of textile fibers</td>
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<td>258</td>
<td>25</td>
<td>25</td>
<td>258</td>
<td>258</td>
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<tr>
<td>22 Manufacture of textile products</td>
<td>3 615</td>
<td>6 663</td>
<td>3 615</td>
<td>3 615</td>
<td>10 476</td>
<td>341</td>
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<tr>
<td>23 Manufacture of furniture and related products</td>
<td>6 291</td>
<td>35 851</td>
<td>6 291</td>
<td>6 291</td>
<td>42 142</td>
<td>826</td>
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</tr>
<tr>
<td>24 Wholesale trade and commission trade, except of motor vehicles and motorcycles</td>
<td>2 470</td>
<td>14 813</td>
<td>2 470</td>
<td>2 470</td>
<td>17 282</td>
<td>107</td>
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<tr>
<td>25 Financial intermediation, except insurance and pension funding</td>
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<td>5 291</td>
<td>1 506</td>
<td>1 506</td>
<td>6 707</td>
<td>3 485</td>
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<td>26 Wholesale trade and commission trade, except of motor vehicles and motorcycles</td>
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<td>478</td>
<td>89</td>
<td>89</td>
<td>507</td>
<td>73</td>
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<td>27 Marketing and distribution of food products</td>
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<td>1 225</td>
<td>268</td>
<td>268</td>
<td>1 530</td>
<td>293</td>
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<td>28 Marketing and distribution of other products</td>
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<td>415</td>
<td>2 030</td>
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<td>256</td>
<td>1 370</td>
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<td>30 Marketing and distribution of equipment and appliances</td>
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<td>582</td>
<td>117</td>
<td>117</td>
<td>622</td>
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<td>31 Marketing of fertilizers, pesticides and similar products, water and soils</td>
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<td>612</td>
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<td>118</td>
<td>730</td>
<td>99</td>
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<td>2 256</td>
<td>567</td>
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<td>2 803</td>
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<td>600</td>
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<td>6 495</td>
<td>1 943</td>
<td>1 943</td>
<td>6 495</td>
<td>597</td>
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<td>4 487</td>
<td>772</td>
<td>772</td>
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<td>43</td>
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<td>45 Land transport, sea transport and related services</td>
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<td>6</td>
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<td>46 Road and water transport</td>
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<td>25</td>
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<tr>
<td>47 Road and water transport, except related to transport of passengers</td>
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<td>1 007</td>
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<td>76</td>
<td>502</td>
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<tr>
<td>49 Road and water transport, except related to transport of passengers</td>
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<td>369</td>
<td>71</td>
<td>71</td>
<td>460</td>
<td>12</td>
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<td>50 Road and water transport, except related to transport of passengers</td>
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<td>24</td>
<td>4</td>
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<td>51 Road and water transport, except related to transport of passengers</td>
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<td>68</td>
<td>68</td>
<td>310</td>
<td>10</td>
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<tr>
<td>52 Road and water transport, except related to transport of passengers</td>
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<td>57</td>
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<td>10</td>
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<td>53 Road and water transport, except related to transport of passengers</td>
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<td>40</td>
<td>268</td>
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<td>20</td>
<td>133</td>
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<td>259</td>
<td>259</td>
<td>1 688</td>
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<td>56 Road and water transport, except related to transport of passengers</td>
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<td>460</td>
<td>2 224</td>
<td>1 352</td>
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<td>57 Road and water transport, except related to transport of passengers</td>
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<td>1 025</td>
<td>267</td>
<td>267</td>
<td>1 271</td>
<td>204</td>
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<td>58 Road and water transport, except related to transport of passengers</td>
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<td>2 444</td>
<td>528</td>
<td>528</td>
<td>3 986</td>
<td>3 504</td>
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<td>59 Road and water transport, except related to transport of passengers</td>
<td>49</td>
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<td>49</td>
<td>49</td>
<td>208</td>
<td>38</td>
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<tr>
<td>60 Road and water transport, except related to transport of passengers</td>
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<td>141</td>
<td>29</td>
<td>29</td>
<td>150</td>
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<td></td>
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<tr>
<td>61 Road and water transport, except related to transport of passengers</td>
<td>69</td>
<td>260</td>
<td>69</td>
<td>69</td>
<td>330</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>62 Road and water transport, except related to transport of passengers</td>
<td>19</td>
<td>71</td>
<td>19</td>
<td>19</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63 Road and water transport, except related to transport of passengers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>64 Road and water transport, except related to transport of passengers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65 Road and water transport, except related to transport of passengers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66 Road and water transport, except related to transport of passengers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Only about one third of the about 586 million tonnes TMR of biomass is used. The remaining unused fraction is in particular due to "ecological rucksacks" of imported goods. Also the significant amounts of erosion can be related to the TMR of biomass. Here, imports into the food industries (NACE code 15) play a major role.

### 1.3 Ranking of NACE branches according to their TMR and/or DMI “load”

In a further step, a procedure is proposed to further arrange the NACE 2-digits economic branches with respect to their relevance for material inputs in terms of DMI and TMR. Two
parameters have been applied in this respect: (1) the absolute level of branches contribution to DMI and TMR in the most recent year by ranking and selecting the top 5 from this, and (2) the increasing trend of DMI or TMR again by ranking and selection of the top 5.

This is exemplified by results for Germany 1991 to 2000 (Schütz 2003) and shown for DMI in Table 14 and for TMR in Table 15.

Table 14: Ranking of the contribution of economic branches (NACE 2-digits) to DMI of Germany 1991 to 2000

<table>
<thead>
<tr>
<th>economic branches</th>
<th>level rank</th>
<th>trend rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Other mining and quarrying</td>
<td>1</td>
<td>37</td>
</tr>
<tr>
<td>10 Mining of coal and lignite; extraction of peat</td>
<td>2</td>
<td>56</td>
</tr>
<tr>
<td>01 Agriculture, hunting and related service activities</td>
<td>3</td>
<td>42</td>
</tr>
<tr>
<td>27 Manufacture of basic metals</td>
<td>4</td>
<td>33</td>
</tr>
<tr>
<td>24 Manufacture of chemicals and chemical products</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>64 Post and telecommunications</td>
<td>36</td>
<td>1</td>
</tr>
<tr>
<td>67 Activities auxiliary to financial intermediation</td>
<td>53</td>
<td>2</td>
</tr>
<tr>
<td>34 Manufacture of motor vehicles, trailers and semi-trailers</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>71 Renting of machinery and equipment and of personal and household goods</td>
<td>54</td>
<td>4</td>
</tr>
<tr>
<td>72 Computer and related activities</td>
<td>43</td>
<td>5</td>
</tr>
</tbody>
</table>

For example, the high contribution of NACE 14 to DMI is mainly due to the quantitative relevance of NACE 14.1 (quarrying of stone), NACE 14.2 (quarrying of sand and clay), and NACE 14.4 (production of salt). The highest increasing trend was however found for NACE 64 (post and telecommunications), a result that should be further analyzed to find out about the reasons for this trend.

Disaggregation of NACE 2-digits data is therefore rather an empirical procedure based on the specific results of the study. To propose a general structure seems not very useful.

Furthermore, disaggregation of MFA data to NACE branches below the 2-digits level is a very demanding and time consuming task, especially for imports and exports. Therefore, a procedure as described before appears very useful in order to evaluate branches of priority concern. Disaggregations should be carried out by national statistical offices having access to the data in electronic format and to keys for conversion of different systems of classification of statistical data.

Looking at TMR NACE 10 is ranking on top in front of NACE 14. This is due to high unused extractions associated with NACE 10.1 (hard coal mining) and NACE 10.2 (lignite mining).
Table 15: Ranking of the contribution of economic branches (NACE 2-digits) to TMR of Germany 1991 to 2000

<table>
<thead>
<tr>
<th>economic branches</th>
<th>NACE Rev.1 (2-digits) codes</th>
<th>level rank</th>
<th>trend rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Mining of coal and lignite; extraction of peat</td>
<td>1</td>
<td>&lt; 56</td>
</tr>
<tr>
<td>14</td>
<td>Other mining and quarrying</td>
<td>2</td>
<td>&gt; 28</td>
</tr>
<tr>
<td>27</td>
<td>Manufacture of basic metals</td>
<td>3</td>
<td>&gt; 24</td>
</tr>
<tr>
<td>01</td>
<td>Agriculture, hunting and related service activities</td>
<td>4</td>
<td>&gt; 33</td>
</tr>
<tr>
<td>45</td>
<td>Construction</td>
<td>5</td>
<td>&lt; 42</td>
</tr>
<tr>
<td>64</td>
<td>Post and telecommunications</td>
<td>35</td>
<td>&gt; 1</td>
</tr>
<tr>
<td>61</td>
<td>Water transport</td>
<td>54</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>34</td>
<td>Manufacture of motor vehicles, trailers and semi-trailers</td>
<td>6</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>72</td>
<td>Computer and related activities</td>
<td>49</td>
<td>&gt; 4</td>
</tr>
<tr>
<td>67</td>
<td>Activities auxiliary to financial intermediation</td>
<td>55</td>
<td>&gt; 5</td>
</tr>
</tbody>
</table>

1.4. Allocation of material output flows to NACE rev.1 sectors.

In this part of the study major groups of material output flows were allocated to economic sectors directly releasing these outputs. Major groups of material outputs are exported commodities and outputs to the environment comprising waste disposal, emissions to air, emissions to water, and dissipative use of products (after the EUROSTAT Methodological Guide on MFA).

For exports the sector allocation is in principle the same as for imports (see chapter 1.1). Emissions to air are subject to the established NAMEA tables for air emissions that are analysed here to evaluate how they correspond to the accounting of air emissions after the EUROSTAT Methodological Guide on economy-wide material flow accounting. For other outputs to the environment, the availability of data for sector allocations was checked. For waste, and in particular for waste disposal, the sectoral data for Germany 1995 provided by the Federal Statistical Office in the physical input-output table (PIOT) 1995 were taken as a basis for this (StBA 2001). It was further evaluated which efforts are currently undertaken in the EU to provide information of this kind.

The result is a compilation of major categories of material outputs attributed to the economic sector releasing the output, as well as an analysis of missing information and recommendations on how to proceed towards filling these gaps.

Exports and TMR of exports by economic sectors

Analogously to imports and their hidden or indirect flows, exports and associated hidden or indirect flows were allocated to economic sectors delivering the commodities with associated indirect material requirements to the rest of the world. This indicates the total resource
requirements for the exporting sectors which obviously play an increasingly important role for the economic performance of industrialized countries (see also chapter 3). The latter is especially true for Germany and the sectoral allocations of direct commodity exports (absolute), their indirect or hidden flows, and the resulting total material requirement (TMR) is shown as an example for Germany in 2000 versus 1991 (Table 16). In addition the total requirements for non-renewable materials are shown to indicate to which extent exports are based on a rather unsustainable resource basis.

The material basis of exports of Germany is significantly less (52%) based on non-renewables than DMI (about 80%). The share of non-renewables of exports had even declined by 13% from 1991 to 2000 whereas total exports had increased by 30% over the same period. Thus, the material basis of German exports had developed towards a more sustainable basis during the 1990s. However, this cannot be found for total material requirements of German exports which were by about 80% based on non-renewables and declined only slightly (by 2%) from 1991 to 2000. This was mainly due to NACE 27 (Manufacture of basic metals) whose TMR of exports had increased by 51% from 1991 to 2000.
Table 16: Exports, their indirect or hidden flows, and total resource requirements (TMR) for Germany 2000 vs. 1991 attributed to major material aggregates and economic sectors (NACE 2-digits).

NACE Rev.1 summary: Germany

<table>
<thead>
<tr>
<th>NACE 2000 tons</th>
<th>NACE 01</th>
<th>17.177</th>
<th>95%</th>
<th>58.529</th>
<th>66%</th>
<th>75.706</th>
<th>72%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestry, logging and related service activities</td>
<td>02</td>
<td>5.614</td>
<td>-25%</td>
<td>4.882</td>
<td>-25%</td>
<td>10.496</td>
<td>-25%</td>
</tr>
<tr>
<td>Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing</td>
<td>05</td>
<td>200</td>
<td>30%</td>
<td>66</td>
<td>31%</td>
<td>266</td>
<td>30%</td>
</tr>
<tr>
<td>Mining of coal and lignite; extraction of peat</td>
<td>10</td>
<td>2.830</td>
<td>-62%</td>
<td>4.901</td>
<td>-74%</td>
<td>7.731</td>
<td>-70%</td>
</tr>
<tr>
<td>Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying</td>
<td>11</td>
<td>1.249</td>
<td>107%</td>
<td>279</td>
<td>110%</td>
<td>1.528</td>
<td>108%</td>
</tr>
<tr>
<td>Mining of uranium and thorium ores</td>
<td>12</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
</tr>
<tr>
<td>Mining of metal ores</td>
<td>13</td>
<td>203</td>
<td>-46%</td>
<td>3.652</td>
<td>115%</td>
<td>3.855</td>
<td>86%</td>
</tr>
<tr>
<td>Other mining and quarrying</td>
<td>14</td>
<td>32.073</td>
<td>-11%</td>
<td>10.364</td>
<td>-13%</td>
<td>42.437</td>
<td>-11%</td>
</tr>
<tr>
<td>Manufacture of food products and beverages</td>
<td>15</td>
<td>30.270</td>
<td>23%</td>
<td>160.682</td>
<td>10%</td>
<td>190.952</td>
<td>12%</td>
</tr>
<tr>
<td>Publishing, printing and reproduction of recorded media</td>
<td>22</td>
<td>820</td>
<td>24%</td>
<td>5.079</td>
<td>24%</td>
<td>5.900</td>
<td>24%</td>
</tr>
<tr>
<td>Manufacture of coke, refined petroleum products and nuclear fuel</td>
<td>23</td>
<td>20.306</td>
<td>93%</td>
<td>7.171</td>
<td>-20%</td>
<td>27.478</td>
<td>42%</td>
</tr>
<tr>
<td>Manufacture of chemicals and chemical products</td>
<td>24</td>
<td>34.475</td>
<td>48%</td>
<td>22.749</td>
<td>-39%</td>
<td>57.224</td>
<td>-6%</td>
</tr>
<tr>
<td>Manufacture of rubber and plastic products</td>
<td>25</td>
<td>14.457</td>
<td>87%</td>
<td>14.457</td>
<td>87%</td>
<td>14.457</td>
<td>87%</td>
</tr>
<tr>
<td>Manufacture of other non-metallic mineral products</td>
<td>26</td>
<td>11.121</td>
<td>33%</td>
<td>13.655</td>
<td>46%</td>
<td>24.776</td>
<td>40%</td>
</tr>
<tr>
<td>Manufacture of basic metals</td>
<td>27</td>
<td>38.748</td>
<td>21%</td>
<td>625.772</td>
<td>53%</td>
<td>664.520</td>
<td>51%</td>
</tr>
<tr>
<td>Manufacture of fabricated metal products, except machinery and equipment</td>
<td>28</td>
<td>895</td>
<td>54%</td>
<td>27.613</td>
<td>53%</td>
<td>28.508</td>
<td>53%</td>
</tr>
<tr>
<td>Manufacture of machinery and equipment n.e.c.</td>
<td>29</td>
<td>6.894</td>
<td>44%</td>
<td>38.852</td>
<td>44%</td>
<td>43.746</td>
<td>44%</td>
</tr>
<tr>
<td>Manufacture of office machinery and computers</td>
<td>30</td>
<td>239</td>
<td>108%</td>
<td>1.276</td>
<td>198%</td>
<td>1.515</td>
<td>198%</td>
</tr>
<tr>
<td>Manufacture of radio, television and communication equipment and apparatus</td>
<td>32</td>
<td>404</td>
<td>33%</td>
<td>2.160</td>
<td>33%</td>
<td>2.564</td>
<td>33%</td>
</tr>
<tr>
<td>Manufacture of medical, precision and optical instruments, watches and clocks</td>
<td>33</td>
<td>237</td>
<td>32%</td>
<td>237</td>
<td>32%</td>
<td>237</td>
<td>32%</td>
</tr>
<tr>
<td>Manufacture of motor vehicles, trailers and semi-trailers</td>
<td>34</td>
<td>10.826</td>
<td>78%</td>
<td>57.918</td>
<td>78%</td>
<td>68.743</td>
<td>78%</td>
</tr>
<tr>
<td>Manufacture of other transport equipment</td>
<td>35</td>
<td>574</td>
<td>-58%</td>
<td>4.562</td>
<td>-45%</td>
<td>5.156</td>
<td>-47%</td>
</tr>
<tr>
<td>Manufacture of furniture; manufacturing n.e.c.</td>
<td>36</td>
<td>1.616</td>
<td>26%</td>
<td>15.349</td>
<td>101%</td>
<td>16.965</td>
<td>90%</td>
</tr>
<tr>
<td>Recycling</td>
<td>37</td>
<td>2.589</td>
<td>-40%</td>
<td>2.589</td>
<td>-40%</td>
<td>2.589</td>
<td>-40%</td>
</tr>
<tr>
<td>Electricity, gas, steam and hot water supply</td>
<td>40</td>
<td>197.757</td>
<td>36%</td>
<td>197.757</td>
<td>36%</td>
<td>197.757</td>
<td>36%</td>
</tr>
<tr>
<td>Recreational, cultural and sporting activities</td>
<td>92</td>
<td>1</td>
<td>16%</td>
<td>1</td>
<td>16%</td>
<td>1</td>
<td>16%</td>
</tr>
<tr>
<td>Other service activities</td>
<td>93</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
<td>-100%</td>
</tr>
<tr>
<td>TOTAL SUM</td>
<td>258.802</td>
<td>30%</td>
<td>1.993.473</td>
<td>33%</td>
<td>1.652.275</td>
<td>33%</td>
<td></td>
</tr>
</tbody>
</table>

Non-renewable materials:

| Absolute | 134.414 | 13% | 1.172.465 | 32% | 1.306.880 | 30% |
| Share of Total | 52% | -13% | 84% | -1% | 79% | -2% |

Material outputs to the environment by economic sectors

Next, the major components of material outputs to the environment (see also Matthews et al. 2000 and Eurostat 2001a) were analyzed on the sectoral level of NACE 2-digits. These are: emissions to air, emissions to water, final waste disposal, dissipative material outputs.

Emissions to air

Emissions to air are commonly very well documented by statistics in the context of environmental data. As an example for the sectoral allocation of the NAMEA type of emissions to air data provided by the Federal Statistical Office Germany were taken (StBA 2001) and compared with respective data compiled after the Eurostat methodology on
economy-wide material flow accounts (Eurostat 2001a) for Germany (Schütz 2003). The result is compiled in Table 17. It shows that major discrepancies between NAMEA type data and MFA data occur for CH₄ and N₂O. For methane the reason for the difference is that MFA data do not include emissions from landfills because these are secondary material outputs to the environment resulting from deposited waste which is counted in MFA as the primary output to the environment. Analogously, emissions of dinitrogen oxide from landfills and agriculture are not counted in MFA to avoid double counting of waste disposed of, respectively fertilizers applied to agricultural land (which is counted in MFA as dissipative use of products – see below). Adjusting the PIOT data and the MFA data to the same system boundaries of accounting actually results in comparable values for the emissions of CH₄ and N₂O. Missing emissions in PIOT are ammonia (NH₃) and CFCs and halons. However, this does not affect the total absolute number for emissions to air. Table 17 further shows specific allocations for emissions to air after the MFA methodology which, however, also does not have significant influence on the overall result as compared with the NAMEA type result.

So, NAMEA type tables for emissions to air are largely comparable with data compiled after the methodology for economy-wide MFA. MFA tables for emissions to air can rather easily be compiled from NAMEA type tables by subtracting the specific emissions of CH₄ and N₂O, and by adding emissions eventually not contained as described before.
<table>
<thead>
<tr>
<th>Activity (NACE)</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Level 6</th>
<th>Level 7</th>
<th>Level 8</th>
<th>Level 9</th>
<th>Level 10</th>
<th>Level 11</th>
<th>Level 12</th>
<th>Level 13</th>
<th>Level 14</th>
<th>Level 15</th>
<th>Level 16</th>
<th>Level 17</th>
<th>Level 18</th>
<th>Level 19</th>
<th>Level 20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, hunting and related service activities</td>
<td>01</td>
<td>42.534</td>
<td>0.39</td>
<td>11</td>
<td>69</td>
<td>67</td>
<td>19</td>
<td>1.028</td>
<td>0.77</td>
<td>44.033</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishing, trapping and related service activities</td>
<td>05</td>
<td>586.5</td>
<td>2.4</td>
<td>0.2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>26.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forestry, logging and related service activities</td>
<td>02</td>
<td>0.8</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.8</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction of coal, lignite; extraction of peat</td>
<td>10</td>
<td>2.367</td>
<td>15.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2.367</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extraction of metal ores, except uranium ores</td>
<td>12</td>
<td>0.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.9</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing of pulp, paper and paper products</td>
<td>21</td>
<td>3.4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>3.4</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacture of coke, refined petroleum products and nuclear fuel</td>
<td>24</td>
<td>0.2</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacture of chemicals and chemical products</td>
<td>25</td>
<td>3.5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mining of coal and of lignite</td>
<td>10</td>
<td>0.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.3</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mining of metal ores, except uranium ores</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NACE Rev.1 summary: Germany 1995</td>
<td>1995</td>
<td>720.0</td>
<td>2.4</td>
<td>1.8</td>
<td>1.4</td>
<td>0.2</td>
<td>0.5</td>
<td>3.8</td>
<td>193</td>
<td>731.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences: MFA Germany to PIOT 95</td>
<td></td>
<td>-26%</td>
<td>-39%</td>
<td>-4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference MFA Germany to PIOT 95</td>
<td></td>
<td>-26%</td>
<td>-39%</td>
<td>-4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 17: Emissions to air for Germany 1995 attributed to economic sectors (NACE 2-digits), and comparison with MFA data for Germany.

NACE Rev.1 summary: Germany 1995

Emissions to air

Source: EEA ETS 1997

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Emissions to water

Emissions to water after the MFA methodology comprise dredged sediments and substances emitted by waste water loads (see also Matthews et al. 2000). As an example the sectoral allocation is shown for Germany 1991 to 2000 (Table 18 based on data from Schütz 2003). Dredging of sediments is attributed to NACE 45 (construction), waste water substances (nitrogen, phosphorus etc.) are resulting from sewage disposal (NACE 90).

Table 18: Emissions to water for Germany 1991-2000 attributed to economic sectors (NACE 2-digits).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>45</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
<td>33794</td>
</tr>
<tr>
<td>Sewage and refuse disposal, sanitation and similar activities</td>
<td>90</td>
<td>3494</td>
<td>3422</td>
<td>3350</td>
<td>3358</td>
<td>3370</td>
<td>3377</td>
<td>3385</td>
<td>3381</td>
<td>3385</td>
<td>3389</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>37288</td>
<td>37216</td>
<td>37144</td>
<td>37152</td>
<td>37163</td>
<td>37171</td>
<td>37179</td>
<td>37175</td>
<td>37179</td>
<td>37182</td>
</tr>
</tbody>
</table>

Waste deposition

Waste accounts on the sectoral level were taken from the Federal Statistical Office Germany (PIOT 1995 – StBA 2001) and compared with data compiled after the MFA methodology (Table 19). MFA categories in the PIOT 1995 account are waste for deposition (mainly waste landfilled) and unused extraction of mining and quarrying. MFA data for this kind of waste disposal are significantly lower than data reported by PIOT. The reason for this discrepancy is that soil excavation for construction is counted in the PIOT as waste deposition under NACE 45, but not in MFA where it is counted under a separate category named landfill and mine dumping. This is because MFA does not account for unused domestic extraction, where excavation is a part of, under the aggregate indicator DPO (Domestic Processed Output) and therefore, excavation is deducted from waste landfilled in the MFA account. MFA data for unused extraction of mining and quarrying are slightly higher than those reported by PIOT because excavation, as described, is contained there instead of under waste landfilled, and because unused extractions of some bulk materials are not covered in the PIOT account (e.g. those of natural stones, sand and gravel, common clays). The total amount of landfilled waste and unused extraction is slightly higher in the MFA account (by 3%) than in PIOT, because of the missing unused extractions for some bulk materials as described before.

So, MFA and PIOT, as an example for a potential NAMEA for waste, are compatible if the different ways of attributing soil excavation for construction (NACE 45) are taken into account.
Table 19: Waste disposal for Germany 1995 attributed to economic sectors (NACE 2-digits), and comparison with MFA data for Germany.

<table>
<thead>
<tr>
<th>NACE Rev.1 summary</th>
<th>Germany</th>
<th>Source: FSOG: PIOT 1995</th>
<th>MFA category</th>
<th>MFA category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste for treatment</td>
<td>1000 tons</td>
<td></td>
<td>Waste for deposition</td>
<td>Unused extraction of mining and quarrying</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
<th>NACE</th>
<th>TOTAL</th>
<th>Waste for recycling</th>
<th>Waste for treatment</th>
<th>Waste for deposition</th>
<th>Unused extraction of mining and quarrying</th>
<th>Other material outputs to environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

MFA Germany: total waste landfilled
- Construction minerals: 15,112 tons
- Industrial minerals: 3,597 tons
- Metals: 18,916 tons
- Fossils: 14,937 tons

MFA Germany: unused abiotic domestic extraction (excl. Excavation and dredging)
- Excavated soil and gravel: 2,078,756 tons
- Stones, sand and gravel: 2,087,667 tons
- Other material outputs to environment: 3,513 tons

**Differences between MFA and PIOT data**
- Waste for recycling: +2%
- Waste for treatment: -26%
- Unused extraction of mining and quarrying: +4%
- Other material outputs to environment: +4%

**Reasons for differences**
- MFA Germany data do not comprise excavated soil not covered by PIOT (e.g. natural stones, sand and gravel, clay) under this category.

**Additional information**
- Table 19 compares the waste disposal for Germany 1995 attributed to economic sectors (NACE 2-digits) with MFA data for Germany. The table shows the total waste disposed for each economic sector, along with additional information such as waste for recycling, waste for treatment, and other material outputs to environment.

**Comparison with MFA data**
- The comparison highlights the differences between MFA and PIOT data, including waste for recycling, waste for treatment, unused extraction of mining and quarrying, and other material outputs to environment. The differences are explained in the reasons for difference section, which mentions that MFA data do not include certain materials (e.g., natural stones, sand and gravel, clay) that are included in PIOT data.
Dissipative material outputs

Dissipative material outputs after the MFA methodology comprise dissipative use of products on agricultural land (fertilizer, manure, pesticides etc.), material lost during transport (e.g. natural gas from pipelines), salt and grit materials dispersed on roads, chemicals accidentally lost, erosion of infrastructures, and abrasion of tyres (see also Matthews et al. 2000). As an example the sectoral allocation is shown for Germany 1991 to 2000 (Table 20 based on data from Schütz 2003). Dissipative use of products by agriculture refers to NACE 01. Dissipative outputs by NACE 60 (transport) are accidents with chemicals on roads and leakages of natural gas by pipeline transport, as well as half of the amounts of abrasion of tyres and erosion of roads. This is just a rough assumption because of missing detailed information. The other halves of the amounts of abrasion of tyres and erosion of roads are attributed to consumption activities of private households. Grit materials dispersed are attributed to NACE 75 (public administration etc.).

Table 20: Dissipative outputs for Germany 1991-2000 attributed to economic sectors (NACE 2-digits).

<table>
<thead>
<tr>
<th>NACE Rev.1 summary: Germany</th>
<th>Dissipative outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, hunting and related service activities</td>
<td>01</td>
</tr>
<tr>
<td>Land transport; transport via pipelines</td>
<td>60</td>
</tr>
<tr>
<td>Public administration and defence; compulsory social security</td>
<td>75</td>
</tr>
<tr>
<td>SUM: Producing sectors</td>
<td>SUM</td>
</tr>
<tr>
<td>Consumption activities of private households domestic</td>
<td>2111</td>
</tr>
<tr>
<td>TOTAL</td>
<td>44756</td>
</tr>
</tbody>
</table>

Disaggregation of economic sectors by relevance for material outputs

Analogously to material inputs, it was examined in how far material outputs to the environment should be further disaggregated than by NACE 2-digits. The same procedure was chosen: two parameters were applied in this respect: (1) the absolute level of sectors contribution to exports, exports incl. indirect flows (TMR), and outputs to the environment, in the most recent year by ranking and selecting the top 5 from this, and (2) the increasing trend of these material aggregates again by ranking and selection of the top 5. Most increasing trends were however only studied for exports and TMR of exports because comprehensive sectoral data for material outputs to the environment were not available due to missing information for waste landfilled except for 1995. The results for Germany 1991 to 2000
(Schütz 2003) are shown for exports in Table 21, for exports TMR in Table 22, and for material outputs to the environment (for the absolute level only) in Table 23.

Direct exports are dominated by NACE 27 (manufacture of basic metals), the most increasing trend, just as for DMI, is found for NACE 30 (office machinery and computers) indicating the growing economic importance of these sectors during recent years. Also exports and their hidden or indirect flows are dominated by NACE 27. The reason for this is that the German economy during the 1990s had increasingly imported raw and semi-manufactured metals to produce increasing amounts of base metals for export (Schütz 2003). Also the most increasing trend of the TMR of exports is due to NACE 30 (office machinery and computers).

NACE 45 (construction) dominates waste landfilled and emissions to water in Germany. This is due to high amounts of construction waste disposed in landfills, respectively high amounts of dredging required to ensure the function of shipping passages. In order to achieve substantial reduction of waste landfilled in the future, and in view of predicted increasing amounts of construction waste arising from growing stocks of infrastructures, it becomes quite obvious that substantial changes will be necessary within the construction sector leading to waste prevention and recycling. Dissipative outputs are dominated by NACE 01 (agriculture) which reflects the high environmental burden caused especially by fertilizer and manure application on conventional farming areas. Emissions to air are dominated by NACE 40 (electricity etc.) and point out the high contribution of the German electricity generation system to emissions of CO$_2$.

Disaggregation of NACE 2-digits data is therefore rather an empirical procedure based on the specific results of the study. To propose a general structure seems not very useful. Furthermore, disaggregation of MFA data to NACE sectors below the 2-digits level is a very demanding and time consuming task, especially for imports and exports. Therefore, a procedure as described before appears very useful in order to evaluate sectors of priority concern. Disaggregations should be carried out by national statistical offices having access to the data in electronic format and to keys for conversion of different systems of classification of statistical data.
Table 21: Ranking of the contribution of economic sectors (NACE 2-digits) to exports of Germany 1991 to 2000.

NACE 2-digits: rankings by level and trend (based on German data 1991-2000)

### Exports

<table>
<thead>
<tr>
<th>NACE</th>
<th>Level</th>
<th>Trend</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>1</td>
<td>&gt;</td>
<td>21</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
<td>&gt;</td>
<td>11</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>&lt;</td>
<td>26</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>&gt;</td>
<td>20</td>
</tr>
<tr>
<td>23</td>
<td>5</td>
<td>&gt;</td>
<td>6</td>
</tr>
<tr>
<td>30</td>
<td>25</td>
<td>&gt;</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>&gt;</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>18</td>
<td>&gt;</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>7</td>
<td>&gt;</td>
<td>3</td>
</tr>
<tr>
<td>01</td>
<td>6</td>
<td>&gt;</td>
<td>5</td>
</tr>
</tbody>
</table>

Total ranks: 31

NACE:
- 27 Manufacture of basic metals
- 24 Manufacture of chemicals and chemical products
- 14 Other mining and quarrying
- 15 Manufacture of food products and beverages
- 23 Manufacture of coke, refined petroleum products and nuclear fuel
- 30 Manufacture of office machinery and computers
- 20 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
- 11 Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
- 21 Manufacture of pulp, paper and paper products
- 01 Agriculture, hunting and related service activities

Table 22: Ranking of the contribution of economic sectors (NACE 2-digits) to the TMR of exports of Germany 1991 to 2000.

NACE 2-digits: rankings by level and trend (based on German data 1991-2000)

### Exports TMR

<table>
<thead>
<tr>
<th>NACE</th>
<th>Level</th>
<th>Trend</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>1</td>
<td>&gt;</td>
<td>12</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>&gt;</td>
<td>17</td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>&gt;</td>
<td>25</td>
</tr>
<tr>
<td>21</td>
<td>4</td>
<td>&gt;</td>
<td>4</td>
</tr>
<tr>
<td>01</td>
<td>5</td>
<td>&gt;</td>
<td>9</td>
</tr>
<tr>
<td>30</td>
<td>27</td>
<td>&gt;</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>13</td>
<td>&gt;</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>&gt;</td>
<td>3</td>
</tr>
<tr>
<td>21</td>
<td>4</td>
<td>&gt;</td>
<td>4</td>
</tr>
<tr>
<td>36</td>
<td>14</td>
<td>&gt;</td>
<td>5</td>
</tr>
</tbody>
</table>

Total ranks: 32

NACE:
- 27 Manufacture of basic metals
- 40 Electricity, gas, steam and hot water supply
- 15 Manufacture of food products and beverages
- 21 Manufacture of pulp, paper and paper products
- 01 Agriculture, hunting and related service activities
- 30 Manufacture of office machinery and computers
- 20 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
- 11 Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
- 21 Manufacture of pulp, paper and paper products
- 36 Manufacture of furniture; manufacturing n.e.c.
### Table 23: Ranking of the contribution of economic sectors (NACE 2-digits) to material outputs to the environment of Germany 1991 to 2000.

**NACE 2-digits: rankings by level (based on German data 1991-2000)**

<table>
<thead>
<tr>
<th>Outputs to the environment</th>
<th>Level MFA categories:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Waste landfilled</td>
</tr>
<tr>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>85</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>92</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>54</td>
</tr>
<tr>
<td><strong>Total ranks</strong></td>
<td><strong>54</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rank</th>
<th>NACE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction</td>
</tr>
<tr>
<td>2</td>
<td>private Households</td>
</tr>
<tr>
<td>3</td>
<td>Electricity, gas, steam and hot water supply</td>
</tr>
<tr>
<td>4</td>
<td>Manufacture of basic metals</td>
</tr>
<tr>
<td>5</td>
<td>Manufacture of food products and beverages</td>
</tr>
<tr>
<td>6</td>
<td>Health and social work</td>
</tr>
<tr>
<td>7</td>
<td>Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials</td>
</tr>
<tr>
<td>8</td>
<td>Manufacture of chemicals and chemical products</td>
</tr>
<tr>
<td>9</td>
<td>Recreational, cultural and sporting activities</td>
</tr>
<tr>
<td>10</td>
<td>Mining of coal and lignite; extraction of peat</td>
</tr>
</tbody>
</table>

### Data availability and recommendations for improvement

Whereas data for material inputs including indirect or hidden flows (the same holds for exports) are available for the EU (Bringezu and Schütz 2001a,b; Eurostat 2002) and can be allocated to economic sectors as described in chapter 1.1, the availability of data for material outputs to the environment is partly severely restricted. Whereas data for emissions to air (EEA and Eurostat) and for most dissipative material outputs (dissipative use of products from agricultural statistics of Eurostat) are available even on the sector level, missing information for the EU is especially encountered for waste disposal, in particular for waste deposition, and for emissions to water, as well as for some dissipative material outputs (Bringezu and Schütz 2001b).

Data for emissions to water and guidance on how to acquire them are available from national studies for Austria, Germany, the Netherlands (Matthews et al. 2000), and Italy (Barbiero et al. 2003). The same holds for Finland (Muukkonen 2000), and partly also for the UK (DETR 1998 and personal communication). For Spain 1990, only sewage sludge dumped at sea was reported (Eurostat 1996). Missing data for emissions to water in Member States of the EU have to be collected which should preferably be done by national experts and reported by the national statistical offices. The sectoral allocation of these material outputs can be based on
the procedure described in this study for Germany. The EC regulation on waste statistics (EC 2002) will provide data on waste released into water, a part of emissions to water, however obviously not on the sector level.

Data for dissipative material outputs to the environment from agriculture comprise fertilizers, manure, pesticides, seeds, and some others (sewage sludge, compost). These data are mostly available for the EU from agricultural statistics (Eurostat or FAO), or can be derived from them (manure estimated based on livestock numbers – Bringezu and Schütz 2001b). Data for dissipative material outputs to the environment other than from agriculture comprise: dissipative losses from roads and tyres, dissipative uses (thawing and grit materials), accidents with chemicals, leakages (natural gas), erosion of infrastructures. These data have been collected for Austria and Germany and the procedure was described in Matthews et al. 2000, they are partly also reported for Italy (Barbiero et al. 2003). As recommended for emissions to water these data should be collected for other EU Member States by national efforts. The sectoral allocation of these material outputs can be based on the procedure described in this study.

Data for waste deposition (especially landfilled waste) are mostly differentiated roughly by municipal waste, industrial waste and sewage. These data and information on their origin are available for Austria, Germany, The Netherlands (Matthews et al. 2000), and for Italy (Barbiero et al. 2003). They are partly also available for other Members of the EU, especially for Finland (Muukkonen 2000), the UK (DETR 1998 and personal communication), and for Sweden (Isacsson et al. 2000, Bergstedt and Linder 1999). Based on these available data for Member States, missing data for waste disposal were estimated by the Wuppertal Institute leading to a first comprehensive preliminary account for deposited waste in the EU and Member States (Bringezu and Schütz 2001b). For this, municipal waste was estimated on a per capita basis, industrial waste on the basis of GDP. No further breakdown to economic sectors was made.

Overall, data for material outputs to the environment collected and organized as described in this study for Germany would lead to an EU-wide database pointing out the economic sectors contributions to DPO (domestic processed outputs), and, in combination with domestic unsued extraction, also the sectors contribution to TDO (total domestic output) as defined by the Eurostat guide (Eurostat 2001a). This would be an important source of information for policy makers in order to address the main actors in the context of sustainable development strategies of the EC.
Clearly, especially data for final waste disposal, and in particular for waste deposition, require considerable further efforts in the EU to derive representative accounts comparable to e.g. the sectoral waste account for Germany 1995 as described before. To meet the objectives of the EC thematic strategy on the prevention and recycling of waste (Commission of the European Communities 2003a) quantitative as well as qualitative data and information on disposed of waste is required. The EC regulation on waste statistics (EC 2002) provides the basis for this kind of information by the Statistical Offices within the EU and Eurostat. The European Topic Center on Waste and Material Flows at EEA (ETC-WMF) established an electronic database for waste (WasteBase - http://waste.eionet.eu.int/wastebase) which includes waste quantities, policies, plans, strategies, and instruments. Further development should aim at providing more comprehensive and consistent information on waste flows in Europe on the level of economic branches and with a focus on final waste disposal, in particular waste deposition, to meet the requirements of economy-wide material flow analysis as a tool for providing comprehensive information to decision makers. Data and information provided by the Federal Statistical Office Germany for final waste disposal as described before may serve as an example in this respect. A possibility to get the same kind of information for other European countries as well would be the establishment of physical input-output tables by Member States as proposed by Eurostat (Eurostat 2001a).

Furthermore, recent development of material flow accounts towards weighting based on environmental impacts (Van der Voet et al. 2003) may be analyzed with regards to possible application for the economic branch accounts as well.

2. Cross-country comparison of MFA of the EU, Member States, and Non-EU countries inclusive Accession Countries

The objective of the following chapter is to analyse in a cross-country comparison the dynamics of the material flows indicators DMI, DMC, and TMR with regards to their major components and relation to economic growth. For this, international material flow data available to date were at first gathered comprehensively as entire time series and analyzed with respect to their comparability, respectively potential restrictions with regards to obvious data gaps or methodological discrepancies as compared with the reference Eurostat guide on economy-wide MFA. Second, cross-country data in time series selected by this procedure were compared on the aggregate levels of absolute values and per capita values. Third, this
database was analyzed by decomposition into the major components of the material flows indicators, in order to evaluate reasons and drivers of changes over the respective time periods. Finally, the trends of the material productivities of DMI, DMC and TMR were analyzed with regards to coupling or decoupling of material use with/from GDP, and reasons for these developments were evaluated. This chapter will, thus, indicate the usefulness and informative capability of the MFA indicators in a comparative manner and provide quantitative, reproducible and reliable information on important trends of the physical basis of the national economies studied in comparison with the EU and AC average reference values. Chapter 2.1 is on cross-country comparison of basic data and composition of DMI, chapter 2.2 is on the same issues for DMC, and chapter 2.3 represents the same basic concept for TMR. Chapter 2.4 describes the results of analysis of the material productivities of DMI, DMC and TMR.

DMI and DMC of the EU-15 and its Member States as well as of the Accession and Candidate Countries of the EU will be further analyzed by the Wuppertal Institute in a study for DG Environment of the European Commission. The aim of the study is to identify main limits to the derivation of consistent and comparable data sets for material flows and resource use indicators. Further, solutions are to be developed to overcome data problems and to derive a consolidated database that will be available most probably in autumn 2004.

2.1. Cross-country comparison with regard to Direct Material Input (DMI).

Datasets available (or being currently elaborated) internationally in time series for DMI were analyzed with regards to sources, time periods, availability of data for the four major material groups (fossil fuels, minerals, biomass and other imported compound products not clearly attributable to the previous three material groups) (Table 24). These datasets were in general grouped by Non-European countries, the EU-15 and its Member states, countries acceding the EU in 2004 (AC 10), plus countries acceding the EU in 2007 (AC 12), plus countries with applied (Croatia) and received (Turkey) Candidate status for EU accession (AC 14), and European Non-EU countries (Iceland, Norway). For the EU-15 and its Member States, in general two datasets currently exist from different studies for Eurostat (Bringezu and Schütz 2001b, Eurostat 2002), and especially for Denmark, Italy and Spain recently published databases by the national statistical offices exist in addition. Table 24 describes major
differences between these multiple sources, comments on the sources and the differences, and highlights the datasets selected for further analysis in this study.

Two general points concerning methodology are important for differences between multiple databases for the EU-15 and Member States: the accounting for domestic biomass harvest by grazing of livestock and the accounting for the total crude ore extraction of metals (and some other minerals) instead of counting the metals (or minerals) contents of the crude ore only. This has been described in detail in a previous report to Eurostat (Schütz 2003).

Consequently, diverging databases still require harmonization based on both data analyses and evaluation of different methodologies. Especially the example of Italy shows that an in-depth specific national study may come to significantly different results as regards both the level and trend of material flows indicators as compared with the rather rough databases elaborated mostly from international statistics (e.g. the revised Eurostat DMI for Italy –Eurostat 2002- is up to 20% lower than DMI published recently by Statistics Italy -Barbiiero et al. 2003- and the trend is almost completely different and largely even showing contrary developments of DMI). The same was found for Portugal where recent data from Statistics Portugal (Monteiro 2003) indicated different levels and also different trends of DMI for Portugal from 1990 to 2000 as compared with the revised Eurostat database (Eurostat 2002). This supports the recommendation of the author of this study to Eurostat (Schütz 2003) to encourage and support official statistical offices in the Member States to perform their specific national material flows studies in line with the Eurostat guide.

Mainly for the reasons described before, i.e. accounting for crude ores and minerals in line with the Eurostat guide, and integration of the newly available specific national material flows data, the revised database of the Wuppertal Institute of this study was preferred for further cross-country analysis of the EU-15 and other economies, being well aware that substantial further improvement and efforts to achieve harmonization of the accounts is required.

The databases for EU Accession Countries and Non-EU European countries are based on the respective previous data set C elaborated by the Wuppertal Institute for DG Environment in the so-called “zero study” (Moll et al. 2003). However, the dataset used in this study represents a substantial further development of dataset C, in so far as basic statistical data were updated and extended for the year 2000 (especially, available original data for imports and exports were taken from the respective national statistical offices), and by accounting for DMC in addition to DMI. Still, the database for Accession and Candidate countries has to be characterized as preliminary for two major reasons: (1) data are mostly from international statistics and may be incomplete as compared with specific national data, and (2) it has to be
noted that data for the total of Accession Countries (AC 10, AC 12, AC 14) are not absolutely consistent with the requirements of economy-wide MFA as they do not account specifically for the extra foreign trade (imports and exports) with economies other than those belonging to the AC, as it is the case for the EU-15 as a whole economy. Foreign trade of the AC as whole economies comprises here the sums of the total foreign trade and, thus, includes also internal trade of the AC. This problem could not be solved due to restricted data availability in this study, but it can be assumed that the mistake made by including the internal (intra) trade of the AC is minor in terms of the aggregated indicators DMI and DMC. DMI of the AC is rather dominated by domestic extraction and the total imports share of the DMI of the AC is only about 20%. Correspondingly, the share of DMC of DMI of the AC is about 85% showing that exports in total have minor influence on the domestic material use of the AC. Material flow data for Croatia and Iceland are published for the first time in this study, whereas the bad (international) data availability made it impossible to derive such accounts for Liechtenstein.
Table 24: International data availability for DMI

<table>
<thead>
<tr>
<th>Non-Europe</th>
<th>Source(s)</th>
<th>Time period</th>
<th>4 major material groups available</th>
<th>Major differences between multiple sources</th>
<th>Comments on sources and differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Poldy and Foran 1999</td>
<td>1975-1991</td>
<td>NO</td>
<td>characterized as not sufficient</td>
<td></td>
</tr>
<tr>
<td>Bolivia</td>
<td>Lukesch et al. 2002</td>
<td>1995</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>Machado and Mathis 2003</td>
<td>1975-1995</td>
<td>YES</td>
<td>construction minerals underestimated</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>Chen and Qiao 2000</td>
<td>1990-1996</td>
<td>YES</td>
<td>breakdown for imports not available, but as imports make up only 4.9% of DMI, this error seems rather acceptable</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>El Mahdi 1999</td>
<td>1995</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laos</td>
<td>Project SEATRANS</td>
<td>unknown</td>
<td>unknown</td>
<td>reports not yet available (October 2003)</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>Project SEATRANS</td>
<td>unknown</td>
<td>unknown</td>
<td>reports not yet available (October 2003)</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>Project SEATRANS</td>
<td>unknown</td>
<td>unknown</td>
<td>reports not yet available (October 2003)</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>Adriaanse et al. 1997</td>
<td>1975-1994</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venezuela</td>
<td>L君子ch et al. 2002</td>
<td>1995</td>
<td>NO</td>
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<td>Vietnam</td>
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<td>unknown</td>
<td>reports not yet available (October 2003)</td>
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</table>

<table>
<thead>
<tr>
<th>European Union (15)</th>
<th>Source(s)</th>
<th>Time period</th>
<th>4 major material groups available</th>
<th>Major differences between multiple sources</th>
<th>Comments on sources and differences</th>
</tr>
</thead>
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<tr>
<td>EU-15a</td>
<td>WI - this study</td>
<td>1980-1997</td>
<td>YES</td>
<td>different methodology for estimation of grazing and other specific reasons as described for EU Member States below</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>methodology for grazing needs further research towards harmonization; more specific country studies required to improve EU account</td>
<td></td>
</tr>
<tr>
<td>European Union (15)</td>
<td>EU-15 b</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
<td>data for domestic extraction of ores are not in line with Eurostat Guide on economy-wide MFA; foreign trade data are incomplete; aggregation to only 3 major groups seems not reasonable</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------</td>
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<td>-----------</td>
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<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Austria</td>
<td>A 1</td>
<td>WI</td>
<td>1980-1997</td>
<td>YES</td>
<td>no significant differences</td>
</tr>
<tr>
<td>Austria</td>
<td>A 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
<td>different methodology for estimation of grazing</td>
</tr>
<tr>
<td>Austria</td>
<td>A 3</td>
<td>Schandl 1998 (IFF); Gerhold and Petrovic 2000</td>
<td>1960-1997</td>
<td>YES</td>
<td>WI prefered because of consistent aggregation to 4 major material groups; breakdown by 4 major material groups only for 1991 to 2000 because of interpretation of results referring to the economy of the re-united Germany</td>
</tr>
<tr>
<td>Belgium and Luxembourg</td>
<td>B/L 1</td>
<td>WI</td>
<td>1980-1997</td>
<td>YES</td>
<td>different methodology for estimation of grazing</td>
</tr>
<tr>
<td>Belgium and Luxembourg</td>
<td>B/L 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
<td>specific country data analysis</td>
</tr>
<tr>
<td>Denmark</td>
<td>DK 1</td>
<td>WI</td>
<td>1980-1997</td>
<td>YES</td>
<td>WI accounts for metals total crude ore weight after Eurostat Guide on economy-wide MFA based ony data from Univ.Oulu, Thule Institute</td>
</tr>
<tr>
<td>Denmark</td>
<td>DK 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
<td>different methodology for estimation of grazing</td>
</tr>
<tr>
<td>Denmark</td>
<td>DK 3</td>
<td>Stat.Denmark</td>
<td>1981,1990,1997</td>
<td>YES</td>
<td>no significant differences</td>
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<tr>
<td>Finland</td>
<td>FIN 1</td>
<td>Univ.Oulu and WI</td>
<td>1970-1999</td>
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</tr>
<tr>
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<td>FIN 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
<td>WI preferred because of consistent aggregation to 4 major material groups; breakdown by 4 major material groups only for 1991 to 2000 because of interpretation of results referring to the economy of the re-united Germany</td>
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<tr>
<td>Finland</td>
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</tr>
<tr>
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<td>WI</td>
<td>1980-1997</td>
<td>YES</td>
<td>different methodology for estimation of grazing</td>
</tr>
<tr>
<td>France</td>
<td>F 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
<td>no significant differences</td>
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<tr>
<td>Germany</td>
<td>D 1</td>
<td>WI</td>
<td>1980-2000</td>
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<td>different methodology for estimation of grazing</td>
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<tr>
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<td>WI</td>
<td>1980-1997</td>
<td>YES</td>
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<td>Greece</td>
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<td>Eurostat-IFF</td>
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<td>Year</td>
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<td>Eurostat-IFF</td>
<td>1980-2000</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Italy</td>
<td>I 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
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<tr>
<td>Italy</td>
<td>I 3</td>
<td>Stat. Italy</td>
<td>1980-1998</td>
<td>YES</td>
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<tr>
<td>Netherlands</td>
<td>NL 1</td>
<td>WI</td>
<td>1975-1997</td>
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<tr>
<td>Netherlands</td>
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<td>Eurostat-IFF</td>
<td>1980-2000</td>
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<tr>
<td>Portugal</td>
<td>P 1</td>
<td>WI and Statistics Portugal</td>
<td>1980-2000</td>
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<tr>
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<td>Eurostat-IFF</td>
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<td>1990-2000</td>
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<tr>
<td>Spain</td>
<td>E 1</td>
<td>WI</td>
<td>1980-1997</td>
<td>YES</td>
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<tr>
<td>Spain</td>
<td>E 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>E 4</td>
<td>Univ. Barcelona</td>
<td>1980-2000</td>
<td>NO</td>
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<td>Sweden</td>
<td>S 1</td>
<td>WI</td>
<td>1980-1997</td>
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<tr>
<td>Sweden</td>
<td>S 2</td>
<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
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</tr>
<tr>
<td>UK</td>
<td>UK 1</td>
<td>WI</td>
<td>1970-1999</td>
<td>YES</td>
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<tr>
<td>UK</td>
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<td>Eurostat-IFF</td>
<td>1980-2000</td>
<td>NO</td>
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<tr>
<td>Cyprus</td>
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<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td></td>
<td>S casny et al. 2003</td>
<td>1990-2000</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
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</tr>
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<td>Estonia</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
</tr>
<tr>
<td>Hungary</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
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</tr>
<tr>
<td>Latvia</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
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<tr>
<td>Lithuania</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
</tr>
<tr>
<td>Lithuania</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
</tr>
<tr>
<td>Malta</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
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</tr>
<tr>
<td>Poland</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
</tr>
<tr>
<td>Slovakia</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
</tr>
<tr>
<td><strong>EU Accession 2007</strong></td>
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<td></td>
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</tr>
<tr>
<td>Bulgaria</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
</tr>
<tr>
<td>Romania</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
<td></td>
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<tr>
<td><strong>EU Candidates</strong></td>
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<tr>
<td>Croatia</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td>preliminary first dataset in this study, requires further improvement</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Source</td>
<td>Period</td>
<td>Data Quality</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
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<td></td>
</tr>
<tr>
<td>Iceland</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liechtenstein</td>
<td>WI - this study</td>
<td>Data not sufficient, severe gaps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>WI - this study</td>
<td>1992-2000</td>
<td>YES</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Selection for this study**

Note: 4 major material groups are fossil fuels, minerals, biomass, and other imported compound products not attributable to one of the other three specific material groups.

Sources:
- Project SEATRANS: www.seatrans.net
- Eurostat-IF: Eurostat 2002
- WI: Bringezu and Schütz 2001a,b; Schütz 2003
- Stat.Finland: Muukkonen 2000
- Stat.Italy: Barbiero et al. 2003
- Univ.Barcelona: Canellas-Bolta et al. 2003
- Univ.Oulu: Mäenpää et al. 2000
- Statistics Portugal: Monteiro 2003
Table 25 gives a summary of DMI data in the format described before. Among the total of 43 economies studied (39 countries plus EU-15, AC 10, AC 12, AC 14), the absolute volume of DMI in the latest year of the period for which data were available was highest for the EU-15, followed by the USA, China, Brazil and Japan. Contrary, Malta, Iceland, Cyprus, Slovenia and Lithuania had the lowest DMI in absolute terms. The highest average annual increase of DMI was observed for Croatia (at 10% p.a. from 1992 to 2000). Next ranges China at 6% average increase of DMI per year between 1990 and 1996, which deserves special attention because of the high absolute level of China’s direct material requirements. The same holds for Brazil at 6% average annual DMI increase between 1975 and 1995. All Non-European countries (n=6) had increased their absolute DMI over the periods studied. Contrary, the EU and its dominating Member States France, Germany, Italy and the UK (in terms of DMI and GDP as well) had kept their DMI rather constant over the last two decades of the 20th century. The Accession and Candidate Countries in total had only slightly increased their DMI from 1992 to 2000, but with rather big differences between individual countries. Whereas Croatia, Slovenia and Turkey had increased their DMI significantly from 1992 to 2000, the Czech Republic and Romania succeeded in reducing their DMI in absolute terms over the same period. The dominating DMI contributors of AC in 2000 were Poland, Czech Republic, and Turkey, characterized by rather moderate increase of DMI, absolute reduction of DMI, respectively absolute increase of DMI, a very diverting development that will be further analyzed in the following. Also Iceland showed a moderate increase of DMI, whereas Norway had increased its DMI by almost one third from 1992 to 2000, i.e. about 4% per year on the average.

On a per capita basis, the direct material requirements show a different distribution (Table 25). Here, Northern European countries dominate the top five, especially Iceland and Norway at 59 tonnes DMI per capita each, followed by Finland (45 t/cap) and Ireland (43 t/cap), and Australia holds position 4 at 45 tonnes DMI per capita. Contrary, the high absolute DMI of China is relativated by the lowest DMI per capita among all economies studied, i.e. 3 t/cap. Next low DMI per capita was found for Turkey (6 t/cap), Bolivia (6 t/cap), Romania (7 t/cap), and Egypt (8 t/cap), all developing or newly industrializing countries. Like for absolute DMI, also DMI per capita had increased relatively most in Croatia at 10% per year on the average from 1992 to 2000. Similarly, high absolute DMI as well as per capita increases of DMI were found especially for Brazil, China, and Slovenia. Also Norway had increased its DMI per capita relatively much at about 3% on the average per year from 1992 to 2000, whereas Iceland had kept the same high level of DMI per capita over that period. The EU-15 ranks in
the midfield with 19 t/cap in 1997, its Accession and Candidate countries have little lower DMI per capita with descending order from AC-10 (16 t/cap), over AC-12 (14 t/cap) to AC-14 (11 t/cap). Their accession to the EU will therefore most probably indicate slightly lower values of the direct material inputs per capita of the European Union. This assumption is further supported by the observation that the DMI per capita of the AC increased only slightly (by 1% p.a. each) during 1992 to 2000, close to the stabilization of DMI per capita of the EU-15 over 1980 to 1997. Among the AC, only Estonia had a relatively high and increasing DMI per capita (40 t/cap in 2000, 2% increase p.a. since 1992), for reasons that will be described later.

All developing countries represented in this study are characterized by the lowest shares of imports of DMI among all countries studied, from 2% for Bolivia to 6% for Venezuela (Table 25). Contrary, the EU Member States Belgium/Luxembourg and the Netherlands held the highest imports contributions to DMI at 63% and 60%, respectively. Next ranked Malta at 59%, Slovakia at 40%, and Japan at 37%. Among these, Slovakia had even doubled its imports share of DMI from 1992 to 2000, and also Malta had increased this share significantly over that time period (times 1.2). The EU-15 as a whole ranks in the lower midfield as regards the imports share of DMI (18%), close to the same ratios for its Accession and Candidate countries as entire economies with about 19% to 20%.

Interestingly, all economies studied had increased their shares of imports of DMI over the observation periods, indicating the increasing globalization in terms of accelerated foreign trade especially during the 1990s (see also chapter 3). Most pronounced average annual increases of this ratio were found for Slovakia (factor 0,22 p.a.), Poland (0,21), Estonia (0,19), China (0,19), and AC-10 (0,18). Thus, especially the newly industrializing economies (NIC) of Eastern Europe got increasingly involved in foreign trade after transition of their economies in the early 1990s. This is in agreement with results showing increasing imports by the EU from NIC over that period (see chapter 3). But also the development in China deserves special attention with regards to future material requirements on the global scale, and this will be further discussed in chapter 2.3 on Total Material Requirements - TMR. The EU-15 had increased its imports share of DMI at a relatively low average annual rate (factor 0,06 p.a.) from 1980 to 1997. This was much less than its Accession and Candidate countries at factor 0,18 p.a. in AC-10, and factor 0,16 p.a. for both AC-12 and AC-14. So, despite of similar shares of imports of DMI in the late 90s, the accelerated development especially in the Eastern European AC shows a possible trend towards relatively higher global direct material requirements from abroad in an extended EU.
Among the 39 economies studied for the contribution of the four major components to DMI, minerals were found to be the dominant constituent of DMI in 25 economies, indicating the high relevance of construction minerals for direct material requirements especially in industrialized and newly industrializing countries of Eastern Europe (Table 26). Contrary, fossil fuels as most important contributor dominated DMI only in 4 of 39 economies, i.e. China and Greece (both for domestic use), the Netherlands and Norway (both for exports mainly). Despite of the high relevance of domestic extraction of minerals (especially iron ores), DMI of Brazil was dominated by biomass (mainly from domestic agriculture). Biomass was also the most important contributor to DMI in nine other economies, more than found to be dominated by fossil fuels. These findings underline the importance of the critical
components of the accounting for DMI, i.e. construction minerals and biomass from agricultural harvest and grazing, which require considerable further attention for improvement and harmonization of international DMI accounts.

The total contribution of non-renewable materials (fossil fuels and minerals) to DMI ranged from as low as 13% in Latvia to as high as 91% in Italy and Egypt. The EU-15 required two third (66%) of its DMI by non-renewables, in AC-10 the share of non-renewables of DMI was 68%, in AC-12 it was 67%, and in AC-14 it was 63%, close to the situation in the EU. A relatively high share of non-renewable materials is likely to indicate a less sustainable material basis of the economy. However, also the resource use by renewable materials (biomass) should be further analyzed critically with regards to unsustainable modes of production due to environmental pressures associated, like minerals fertilizer and pesticides use in agriculture, unsustainable forestry management, and unsustainable fishing practices.

Analysis of the contribution of the four major DMI components to the overall change of DMI over the time periods studied showed that also minerals contributed most to changes of DMI (Table 26). Most of the economies studied, i.e. 29 of 38, had increased their DMI over the periods studied. Only 3 of the 38 economies had reduced their DMI, i.e. Germany, Czech Republic and Romania, all three because of reduced requirements for fossil fuels. The remaining six economies had stabilized their DMI as a result of reduced versus increased requirements for the four major components of DMI.

In total, non-renewables (fossil fuels and minerals) contributed by only as little as 13% to the overall change of DMI in the Netherlands, but by as much as 95% to DMI change in Norway. Change of DMI of the EU-15 was by 44% caused by non-renewables, respective changes in AC-10 by 67%, in AC-12 by 74%, and in AC-14 by 68%. So, DMI of the Accession and Candidate countries was found to be significantly more influenced by non-renewable material requirements, and their development appears under this aspect as less sustainable than development of the EU. However, for the reasons discussed before, also the contribution of renewables to overall changes of material use has to be analyzed under a critical view.

Further decomposition analysis was performed in detail (as far as data were available) to identify the major driving constituents of these changes of DMI over time. The results are:

Brazil: DMI increase mainly caused by domestic metal ores and construction minerals industries, and by domestic agriculture (harvest and grazing);

China: DMI increase mainly caused by domestic metal ores, industrial minerals, and fossil fuels industries;
Japan: DMI increase mainly caused by domestic construction minerals industry (stones), and energy demand from imports (coal and gas);

USA: DMI increase mainly caused by domestic construction minerals industry (stones, sand and gravel), and energy demand from domestic coal and from oil imports;

EU-15: stabilization of DMI as a result of reduction by domestic fossils (lignite and hard coal) and metals and industrial minerals (iron ores, clays) industries, and increase by fossils demand from imported oil, domestic construction minerals industry (stones), domestic agriculture and forestry, and agricultural biomass demand from imports;

Austria: DMI increase mainly caused by domestic construction minerals industry, minerals industry demand for imports, and demand for fossils and biomass from imports;

Belgium and Luxembourg: DMI increase mainly caused by domestic construction minerals industry (stones) and agriculture; demand for biomass from imports (agriculture, forestry), and also fossils, overcompensating reduced domestic fossils extraction;

Denmark: DMI increase mainly caused by domestic fossils industry (oil, gas) and fossils demand by imports;

Finland: DMI increase mainly caused by domestic forestry industry and domestic agriculture, and forestry products demand from imports;

France: stabilization of DMI as a result of reduction by domestic fossils industry (coal, gas) and even more by fossils demand from imports, further by domestic metals (iron ores) and industrial minerals (asbestos) extraction industries, and increase mainly by domestic agriculture, but also by biomass (agriculture, forestry) demand from imports;

Germany: decrease of DMI mainly due to reduction of domestic fossils (lignite and hard coal) partly compensated by increased fossils demand from imports (gas, coal, oil), domestic construction minerals industry (stones) and metals industries from imported ores (especially iron);

Greece: DMI increase mainly caused by domestic lignite industry;

Ireland: DMI increase mainly caused by domestic construction minerals industry (stones) and demand by imports by metals industry, by biomass (agriculture, forestry), and by fossils, partly compensated by reduced domestic agricultural production;

Italy: analysis should include data for 1998 which are available only at ISTAT;
Netherlands: DMI increase mainly caused by domestic biomass demand from imports for processing or consumption;

Portugal: DMI increase mainly caused by domestic construction minerals industry (stones); also by demand by imports especially for fossil fuels and minerals;

Spain: DMI increase mainly caused by domestic construction minerals industry (stones) and domestic agricultural production, increase enforced by demand by imports for fossils, metals and biomass;

Sweden: DMI increase mainly caused by domestic forestry and agriculture and even more by domestic metals and industrial minerals extraction industries, compensated largely by reduction of domestic construction minerals industry (stones), increase enforced by demand for imports, especially for fossils;

UK: stabilization of DMI as a result of increase by domestic oil and gas industries largely compensated by domestic hard coal industry and imported oil and gas, and reduction mainly by domestic construction minerals industry (sand and gravel, clays) partly compensated by increased metals demand from imports (unspecified metals);

West-Germany: DMI increase mainly caused by domestic construction minerals industry and by demand for fossils by imports overcompensating high reductions by domestic fossils industry (hard coal);

AC-10: DMI increase mainly caused by domestic forestry and industrial minerals industries;

Cyprus: DMI increase mainly caused by domestic construction minerals industry;

Czech Republic: decrease of DMI mainly due to domestic fossil fuels industry, compensated partly by increased minerals and other products demand;

Estonia: stabilization (after fluctuating course) of DMI as a result of increased biomass demand by domestic forestry, compensated by reduced domestic fossils demand;

Hungary: DMI increase mainly caused by domestic construction minerals industry and metal manufacturing industry by imports;

Latvia: DMI increase mainly caused by domestic forestry industry and imports of fossil fuels;

Lithuania: stabilization (after fluctuating course) of DMI as a result of increased biomass demand from domestic forestry, compensated by reduced minerals demand by domestic construction minerals industry;
Malta: DMI increase (after fluctuating course) mainly caused by domestic industrial minerals industry by imports;

Poland: DMI increase mainly caused by domestic industrial minerals industry and metals industry by imports;

Slovakia: DMI increase 1992 to 2000 (but even higher levels 93-98) mainly caused by domestic fossil fuels supply from imports;

Slovenia: DMI increase mainly caused by domestic construction minerals industry;

AC-12: DMI increase 1992 to 2000 (but even higher levels 95-98) mainly due to domestic forestry, construction and industrial minerals industries, metals industry by imports, and domestic forestry, compensated largely by reduced domestic fossil fuels industry;

Bulgaria: DMI increase (after fluctuating course) mainly caused by domestic ores and industrial minerals industries;

Romania: decrease of DMI mainly due to domestic fossil fuels industry;

AC-14: DMI increase 1992 to 2000 (but higher levels 96-98) mainly caused by domestic forestry, construction and industrial minerals industries, metals industry by imports, and domestic fossil fuels industry;

Croatia: DMI increase mainly caused by domestic construction minerals industry;

Turkey: DMI increase mainly caused by domestic construction minerals industry, domestic agriculture, and fossil fuels supply from domestic sources and by imports;

Iceland: stabilization (after fluctuating course) of DMI as a result of increased domestic construction minerals industry and reduced domestic agriculture;

Norway: DMI increase (92-96, then rather constantly high level) mainly caused by domestic fossil fuels industry for exports mainly.

This analysis thus provides the basis for identifying priority areas to be addressed by policy in order to proceed towards sustainable (direct) materials management. It shows significantly different patterns for priority areas as follows.

Domestic primary industries have to be addressed exclusively in the developing countries Brazil and China. These are of course only the direct actors concerned, and subsequent analysis has to be performed to identify internal and external market interlinkages with a focus on final demand for these primary products. Similarly, DMI development in Iceland is also driven by primary industries, construction minerals and agriculture, mainly.

72
For the EU-15 and its Member States it can be clearly seen that the domestic construction industries and domestic agriculture play most important roles for the development of DMI, as well as the energy demand supplied via imports. Also, the material demand of metal manufacturing industries via imports and for biomass via imports deserves consideration in this respect. Domestic fossil fuels extraction has considerable influence on DMI in Denmark, France, Germany, Greece and UK, though under different aspects. Denmark and the UK had increased their domestic extraction of fossil fuels with a special view on increasing exports (the same holds for Norway). France had reduced its use of fossil fuels at the expense of increasing the share of nuclear energy. In the re-united Germany, political and market driven forces had led to a decline of the lignite industry in the former GDR, whereas the opposite development took place in Greece where especially the increase of domestic lignite extraction for domestic energy demand was the major reason for the increase of DMI.

The industrialized economies of Japan and USA are characterized by a similar pattern of driving forces for increasing DMI as observed in the EU, with a clear focus on domestic construction industries and energy demand by imports (in the U.S. also energy demand by domestic fossil fuels).

The situation in the Accession and Candidate Countries of the EU is somehow in between developing and industrialized economies. Their DMI is, like in developing countries, largely driven by domestic primary industries, especially construction minerals, fossil fuels, but also the forestry industry deserves special attention in this respect in the Baltic States (Estonia, Latvia, Lithuania). In contrast to industrialized economies, only some (6 of 14) of these mostly newly industrializing economies increased their DMI via imports. These are Hungary and Poland due to increased demand of metals manufacturing industries, Malta due to increased demand of minerals manufacturing industries, and Latvia, Slovakia, and Turkey due to increased energy demands by fossil fuels. If further development in the NIC of Eastern Europe will bring about a similar situation as in the EU, this will most probably lead to increasing direct material requirements supplied via imports.

However, the analysis for changes of DMI should be considered as providing incomplete information only. It should be supplemented by inclusion of the hidden flows of domestic extraction or harvest and of the indirect or hidden flows of imports, i.e. the Total Material Requirement (TMR). Only TMR allows comprehensive analysis for major reasons and drivers of changes of the comprehensive material basis of an economy on a comparable level for domestic extraction and foreign resource requirements. This will be done in a following part of this study (chapter 2.3).
Table 26: Major components of DMI and their contributions to changes over time periods studied (for notes see Table 24).

<table>
<thead>
<tr>
<th>Time period</th>
<th>Non-Europe</th>
<th>European Union (15)</th>
<th>EU Accession 2004</th>
<th>EU Accession 2007</th>
<th>EU Candidates</th>
<th>NON-EU Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Australia</td>
<td>1975-1991</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>Brazil</td>
<td>1975-1995</td>
<td>4%</td>
<td>37%</td>
<td>58%</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>1990-1996</td>
<td>48%</td>
<td>26%</td>
<td>23%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Egypt</td>
<td>1995</td>
<td>25%</td>
<td>66%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>1975-1996</td>
<td>21%</td>
<td>67%</td>
<td>11%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>1975-1994</td>
<td>33%</td>
<td>50%</td>
<td>16%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Venezuela</td>
<td>1995</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td></td>
<td>European Union (15)</td>
<td>1980-1997</td>
<td>22%</td>
<td>44%</td>
<td>33%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Austria</td>
<td>1960-2000</td>
<td>15%</td>
<td>57%</td>
<td>29%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Belgium and Luxembourg</td>
<td>1980-1997</td>
<td>23%</td>
<td>44%</td>
<td>25%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Denmark</td>
<td>1980-1997</td>
<td>24%</td>
<td>39%</td>
<td>34%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Finland</td>
<td>1970-1999</td>
<td>12%</td>
<td>53%</td>
<td>33%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>1980-1997</td>
<td>13%</td>
<td>37%</td>
<td>47%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Germany</td>
<td>1991-2000</td>
<td>26%</td>
<td>53%</td>
<td>18%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Greece</td>
<td>1980-1997</td>
<td>43%</td>
<td>34%</td>
<td>21%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Ireland</td>
<td>1980-1997</td>
<td>11%</td>
<td>43%</td>
<td>44%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Italy</td>
<td>1980-1997</td>
<td>31%</td>
<td>60%</td>
<td>21%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Netherlands</td>
<td>1975-1993</td>
<td>38%</td>
<td>27%</td>
<td>23%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Portugal</td>
<td>1990-2000</td>
<td>13%</td>
<td>56%</td>
<td>28%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Spain</td>
<td>1980-1997</td>
<td>12%</td>
<td>54%</td>
<td>33%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Sweden</td>
<td>1980-1997</td>
<td>11%</td>
<td>50%</td>
<td>37%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>UK</td>
<td>1970-1999</td>
<td>38%</td>
<td>36%</td>
<td>26%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>West-Germany</td>
<td>1960-1990</td>
<td>27%</td>
<td>53%</td>
<td>18%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>AC-10</td>
<td>1992-2000</td>
<td>31%</td>
<td>36%</td>
<td>30%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Cyprus</td>
<td>1992-2000</td>
<td>13%</td>
<td>74%</td>
<td>11%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Czech Republic</td>
<td>1992-2000</td>
<td>38%</td>
<td>40%</td>
<td>18%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Estonia</td>
<td>1992-2000</td>
<td>29%</td>
<td>34%</td>
<td>36%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Hungary</td>
<td>1992-2000</td>
<td>29%</td>
<td>32%</td>
<td>36%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Latvia</td>
<td>1992-2000</td>
<td>6%</td>
<td>7%</td>
<td>85%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Lithuania</td>
<td>1992-2000</td>
<td>19%</td>
<td>9%</td>
<td>72%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Malta</td>
<td>1992-2000</td>
<td>20%</td>
<td>65%</td>
<td>12%</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Poland</td>
<td>1992-2000</td>
<td>34%</td>
<td>38%</td>
<td>27%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Slovakia</td>
<td>1992-2000</td>
<td>28%</td>
<td>38%</td>
<td>32%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Slovenia</td>
<td>1992-2000</td>
<td>22%</td>
<td>46%</td>
<td>28%</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>AC-12</td>
<td>1992-2000</td>
<td>32%</td>
<td>35%</td>
<td>31%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Bulgaria</td>
<td>1992-2000</td>
<td>32%</td>
<td>51%</td>
<td>17%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Romania</td>
<td>1992-2000</td>
<td>34%</td>
<td>16%</td>
<td>49%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>AC-14</td>
<td>1992-2000</td>
<td>31%</td>
<td>33%</td>
<td>35%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Croatia</td>
<td>1992-2000</td>
<td>16%</td>
<td>50%</td>
<td>32%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Turkey</td>
<td>1992-2000</td>
<td>29%</td>
<td>20%</td>
<td>50%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Iceland</td>
<td>1992-2000</td>
<td>6%</td>
<td>53%</td>
<td>40%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Norway</td>
<td>1992-2000</td>
<td>75%</td>
<td>11%</td>
<td>13%</td>
<td>1%</td>
</tr>
</tbody>
</table>

N.A. = Data not available

2.2. Cross-country comparison with regard to Direct Material Consumption (DMC).

Analogously to DMI, datasets available (or being currently elaborated) internationally in time series for DMC were analyzed with regards to sources, time periods, availability of data for the four major material groups (fossil fuels, minerals, biomass and other imported compound products not clearly attributable to the previous three material groups) (Table 27). These datasets were in general grouped by Non-European countries, the EU-15 and its Member states, countries accessioning the EU in 2004 (AC 10), plus countries accessioning the EU in 2007 (AC 12), plus countries with applied (Croatia) and accepted (Turkey) candidate status for EU accession (AC 14), and European Non-EU countries (Iceland, Norway). For the EU-15 and its
Member States, in general two datasets currently exist from different studies for Eurostat (Bringezu and Schütz 2001b, Eurostat 2002), and especially for Denmark, Italy and Spain recently published databases by the national statistical offices exist in addition. Table 27 describes major differences between these multiple sources, comments on the sources and the differences, and highlights the datasets selected for further analysis in this study.

The general points described before as being important for differences in DMI between multiple databases for the EU-15 and its Member States also apply for differences in DMC. Consequently, also diverting DMC databases still require harmonization based on both data analyses and evaluation of different methodologies as proposed before for DMI.

Mainly for the reasons described before, i.e. accounting for crude ores and minerals in line with the Eurostat guide, and integration of the newly available specific national material flows data, the revised database for DMC of the Wuppertal Institute of this study was preferred for further cross-country analysis of the EU-15 and other economies, being well aware that substantial further improvement and efforts to achieve harmonization of the accounts is required.

The DMC databases for EU Accession Countries and Non-EU European countries represent a further development of the previous data set C for DMI only, elaborated by the Wuppertal Institute for DG Environment in the so-called “zero study” (Moll et al. 2003). Still, the database for Accession and Candidate countries has to be characterized as preliminary because data for the total of Accession Countries (AC 10, AC 12, AC 14) are not absolutely consistent with the requirements of economy-wide MFA as they do not account specifically for the extra foreign trade (imports and exports) with economies other than those belonging to the AC, as it is the case for the EU-15 as a whole economy. Foreign trade of the AC as whole economies comprises here the sums of the total foreign trade and, thus, includes also internal trade of the AC. This problem could not be solved due to restricted data availability in this study, but it can be assumed that the mistake made by including the internal (intra) trade of the AC is minor in terms of the aggregated indicators DMI and DMC as described before.

DMC for Croatia and Iceland are published for the first time in this study, whereas the bad (international) data availability made it impossible to derive such accounts for Liechtenstein.
Table 27: International data availability for DMC

<table>
<thead>
<tr>
<th>Non-Europe</th>
<th>Source(s)</th>
<th>Time period</th>
<th>4 major material groups available</th>
<th>Major differences between multiple sources</th>
<th>Comments on sources and differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Poldy and Foran 1999</td>
<td>1975-1991</td>
<td>NO</td>
<td></td>
<td>characterized as not sufficient</td>
</tr>
<tr>
<td>Bolivia</td>
<td>Lukesch et al. 2002</td>
<td>1995</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>Machado and Mathis 2003</td>
<td>1975-1995</td>
<td>YES</td>
<td></td>
<td>breakdown for exports not available, but exports make up only 4% of DMI, so structure of DMC is most likely close to that of DMI</td>
</tr>
<tr>
<td>Egypt</td>
<td>El Mahdi 1999</td>
<td>1995</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>Matthews et al. 2000</td>
<td>1975-1996</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laos</td>
<td>Project SEATRANS</td>
<td>unknown</td>
<td>unknown</td>
<td>different methodology for estimation of grazing and other specific reasons as described for EU Member States below</td>
<td>reports not yet available (october 2003)</td>
</tr>
<tr>
<td>Philippines</td>
<td>Project SEATRANS</td>
<td>unknown</td>
<td>unknown</td>
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<td>reports not yet available (october 2003)</td>
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<td>Eurostat-IFF</td>
<td>1980-2000</td>
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<td>WI preferred because of total crude ore concept not followed by other two sources</td>
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<td>1960-1990</td>
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<td>WI</td>
<td>1992-2000</td>
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<td>preliminary first dataset in this study, requires further improvement</td>
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<td>Liechtenstein</td>
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<td>1992-2000</td>
<td>YES</td>
<td>preliminary, updated database (from Moll et al. 2002), requires further improvement</td>
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**EU Accession 2007**

**EU Candidates**

**NON-EU Europe**

**Selection for this study**

*Note:* 4 major material groups are fossil fuels, minerals, biomass, and other imported compound products not attributable to one of the other three specific material groups.

*Sources:*
- Project SEATRANS: www.seatrans.net
- Eurostat-IFF: Eurostat 2002
WI: Bringezu and Schütz 2001a,b; Schütz 2003
Stat.Finland: Muukkonen 2000
Stat.Italy: Barbiero et al. 2003
Univ.Barcelono: Canellas-Bolta et al. 2003
Univ.Oulu: Mäenpää et al. 2000
Statistics Portugal: Monteiro 2003
Table 28 gives a summary of DMC data in the format described before. Among the total of 42 economies studied (38 countries plus EU-15, AC 10, AC 12, AC 14; compared with DMI only DMC for China is not available), the absolute volume of DMC in the latest year of the period for which data were available was highest for the EU-15, followed by the USA, Brazil, Japan and AC-14, like for DMI (except China). Contrary, Malta, Iceland, Cyprus, Slovenia and Lithuania had the lowest DMC in absolute terms, the same sequence as for DMI. The highest average annual increase of DMC, as for DMI, was observed for Croatia (at 10% p.a. from 1992 to 2000). Next ranges Brazil at 6% increase of DMC per year between 1975 and 1995, which deserves special attention because of the high absolute level of Brazil’s direct material consumption. All three Non-European countries had increased their absolute DMC over the periods studied. Contrary, the EU and its dominating Member States France, Germany, Italy and the UK (in terms of DMC and GDP as well) had kept their DMC rather constant over the last two decades of the 20th century. The Accession and Candidate Countries in total had also kept their DMC rather constant from 1992 to 2000, but with rather big differences between individual countries. Whereas especially Croatia, Slovenia and Turkey had increased their DMC significantly from 1992 to 2000, the Czech Republic, Romania, Estonia, Lithuania and Latvia succeeded in reducing their DMC in absolute terms over the same period. The dominating DMC contributors of AC in 2000 were Poland, Czech Republic, and Turkey, characterized by rather moderate increase of DMC, absolute reduction of DMC, respectively absolute increase of DMC, a very diverting development that will be further analyzed in the following. Iceland showed a constant level of DMC, whereas Norway had decreased its DMC by 26% from 1992 to 2000, i.e. about 3% per year on the average.

So, all in all, the comparative characteristics of absolute DMC of the economies studied are very similar to those of DMI. This could not necessarily be expected, especially because the relation of DMC to DMI varies greatly between the economies due to very different relative levels of exports. This will be described in the following.

On a per capita basis, the domestic material consumptions show a different distribution (Table 28). Here, Northern European countries dominate the top five, especially Iceland at 55 tonnes DMC per capita, followed by Ireland (40 t/cap), Finland (39 t/cap), Estonia (33 t/cap) and Sweden (29 t/cap). Compared with DMI, only Norway had a significantly lower DMC per capita due to high exports of fossil fuels. The lowest DMC per capita was found for Turkey (5 t/cap), Bolivia (6 t/cap), Romania (7 t/cap), Egypt (7 t/cap), and Venezuela (8 t/cap), all developing or newly industrializing countries. Like for absolute DMC, also DMC per capita had increased relatively most in Croatia at 9% per year on the average from 1992 to 2000.
Similarly, high absolute DMC as well as per capita increases of DMC were found especially for Brazil and Slovenia. Norway had decreased its DMC per capita by 4% per year on the average, whereas its DMI per capita had increased relatively much at about 3% on the average per year from 1992 to 2000. The EU-15 ranks in the lower midfield with 18 t/cap DMC in 1997, its Accession and Candidate countries showed significantly lower domestic material consumptions per capita with descending order from AC-10 (14 t/cap), over AC-12 (12 t/cap) to AC-14 (10 t/cap). Their accession to the EU therefore indicates rather slightly lower values for the domestic material consumption per capita of the European Union. This assumption is further supported by the observation that the DMC per capita of the AC had remained constant during 1992 to 2000, like in the EU-15 over 1980 to 1997. Among the AC, only Estonia had a relatively high but decreasing DMC per capita (33 t/cap in 2000, 1% decrease p.a. since 1992), for reasons that will be described later.

All developing countries represented in this study except Venezuela are characterized by high shares of DMC of DMI (above 90%). Venezuela represents an exception as a major global exporter of fossil fuels (oil), similar to Norway but its DMC share of DMI was much lower (52%) than that of Norway (14%) which stands for the lowest DMC/DMI ratio of all economies studied. Similarly, the EU Member States Belgium/Luxembourg and the Netherlands had rather low DMC to DMI ratios at 55% and 53%, respectively, due to their specific role as major entry points for imported commodities to the EU being further exported to other Member States. Also Australia belongs to this group of low DMC/DMI ratios (56%) due to significant exports of raw materials (ores and minerals), a rather atypical characteristic of an industrialized economy. Next ranked Slovakia with a large gap at 73%, and all other economies had DMC/DMI ratios close to 80% and higher. Most of the economies had kept their share of DMC of DMI rather constant, indicating overall relatively stable material flow distributions over time. None of the economies had increased the DMC share of DMI.

Significant decreases of DMC to DMI ratios (factor 0.8 over time periods) were found for Belgium/Luxembourg, the Netherlands, and the Baltic States (Estonia, Latvia, Lithuania). Most obvious decreases of the ratio of DMC to DMI were observed for Norway (factor 0.6 from 1992 to 2000) due to its increasing orientation towards exports of fossil fuels. The EU-15 as a whole ranks high as regards the DMC share of DMI (95%), above the same ratios for its Accession and Candidate countries as entire economies with about 85% to 87%.
Table 28: International data comparison for DMC (for notes see Table 27).

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<tr>
<th>Time period</th>
<th>DMC absolute</th>
<th>Change over period in %</th>
<th>Average change per year in %</th>
<th>DMC share of DMI</th>
<th>DMC per capita</th>
<th>Change over period in %</th>
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<td>6</td>
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<td>419</td>
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</tr>
<tr>
<td>AC-10</td>
<td>1992-2000</td>
<td>1021</td>
<td>3%</td>
<td>0%</td>
<td>85%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Cyprus</td>
<td>1992-2000</td>
<td>167</td>
<td>17%</td>
<td>2%</td>
<td>95%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1990-2000</td>
<td>188</td>
<td>-38%</td>
<td>-4%</td>
<td>81%</td>
<td>0.9</td>
<td>0.09</td>
</tr>
<tr>
<td>Estonia</td>
<td>1992-2000</td>
<td>46</td>
<td>-15%</td>
<td>-2%</td>
<td>82%</td>
<td>0.8</td>
<td>0.10</td>
</tr>
<tr>
<td>Hungary</td>
<td>1992-2000</td>
<td>98</td>
<td>11%</td>
<td>1%</td>
<td>83%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Latvia</td>
<td>1992-2000</td>
<td>39</td>
<td>-10%</td>
<td>-1%</td>
<td>81%</td>
<td>0.8</td>
<td>0.10</td>
</tr>
<tr>
<td>Lithuania</td>
<td>1992-2000</td>
<td>33</td>
<td>-19%</td>
<td>-2%</td>
<td>78%</td>
<td>0.8</td>
<td>0.10</td>
</tr>
<tr>
<td>Malta</td>
<td>1992-2000</td>
<td>5</td>
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<td>1%</td>
<td>96%</td>
<td>1.0</td>
<td>0.12</td>
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<td>1%</td>
<td>89%</td>
<td>1.0</td>
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<td>-2%</td>
<td>73%</td>
<td>0.9</td>
<td>0.11</td>
</tr>
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<td>Slovenia</td>
<td>1992-2000</td>
<td>32</td>
<td>35%</td>
<td>4%</td>
<td>81%</td>
<td>0.9</td>
<td>0.12</td>
</tr>
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<td>EU Accession 2007</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-12</td>
<td>1992-2000</td>
<td>1282</td>
<td>-3%</td>
<td>-3%</td>
<td>86%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>1992-2000</td>
<td>113</td>
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<td>0%</td>
<td>92%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Romania</td>
<td>1992-2000</td>
<td>148</td>
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<td>-2%</td>
<td>89%</td>
<td>0.9</td>
<td>0.12</td>
</tr>
<tr>
<td>EU Candidates</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC-14</td>
<td>1992-2000</td>
<td>1699</td>
<td>7%</td>
<td>1%</td>
<td>87%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Croatia</td>
<td>1992-2000</td>
<td>51</td>
<td>79%</td>
<td>10%</td>
<td>82%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
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<td>366</td>
<td>-32%</td>
<td>4%</td>
<td>93%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>NON-EU Europe</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iceland</td>
<td>1992-2000</td>
<td>15</td>
<td>2%</td>
<td>0%</td>
<td>92%</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Norway</td>
<td>1992-2000</td>
<td>36</td>
<td>-26%</td>
<td>-3%</td>
<td>14%</td>
<td>0.8</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Among the 37 economies studied for the contribution of the four major components to DMC, minerals were found to be the most dominant constituent of DMC in 21 economies, indicating the high relevance of construction minerals for domestic material consumption in industrialized countries and newly industrializing countries of Eastern Europe (Table 29). The only developing country for which these data were available is Brazil whose DMC is dominated by biomass (due to high exports of minerals which contributed much to DMI), the same as for nine other economies in the EU-15 and among Accession and Candidate countries. Among these countries with dominant biomass consumption of DMC is Norway, underlining the high use of DMI of fossil fuels for exports. Contrary to DMI, fossil fuels as single most important contributor to DMC occurred only in one country, Greece (for DMI it were 4 of 40 economies, i.e. China, Greece, the Netherlands and Norway). So, the role of fossil fuels for direct domestic material consumption is much less expressed than for it.
DMI. These findings underline once more the importance of the critical components of the accounting for DMC, as for DMI, i.e. construction minerals and biomass from agricultural harvest and grazing, which require considerable further attention for improvement and harmonization of international DMI and DMC accounts.

The total contribution of non-renewable materials (fossil fuels and minerals) to DMC ranged from as low as 13% in Latvia to as high as 95% in Italy. The EU-15 required two third of its DMC by non-renewables, the same share as for DMI. In AC-10 the share of non-renewables of DMC was slightly higher than in the EU (70%), also in AC-12 (69%), whereas in AC-14 (64%) it was slightly lower. Thus, in the EU as well as in ACC, the shares of non-renewables in DMC were close to the ratios found for DMI. Economies with a relatively high share of non-renewable materials are likely to have less sustainable consumption patterns. However, also the resource consumption by renewable materials (biomass) should be further analyzed critically with regards to unsustainable modes of production due to environmental pressures associated like minerals fertilizer and pesticides use in agriculture, unsustainable forestry management, and unsustainable fishing practices.

Analysis of the contribution of the four major DMC components to the overall change of DMC over the time periods studied showed that a combination of fossils, minerals and biomass contributed most to changes of DMC, followed by minerals as second most important reason for changes (Table 29). Most of the economies studied, i.e. 21 of 36, had increased their DMC over the periods studied. But also 11 of the 36 economies had reduced their DMC. The remaining three economies had stabilized their DMC as a result of reduced versus increased requirements for the four major components of DMC.

In total, non-renewables (fossil fuels and minerals) contributed by only as little as 16% to the overall change of DMC in Norway, but by as much as 96% to DMC change in Cyprus. So, patterns of DMI and DMC changes in Norway point towards opposite directions, DMI change is determined by non-renewables, but DMC change by renewables. This illustrates the potential shortcoming if only one of the two material flow indicators is considered, for example as sole indicator for the economy’s direct resource use. Change of DMC of the EU-15 was by 54% caused by non-renewables, respective changes in AC-10 by 83%, in AC-12 by 89%, and in AC-14 by 76%. So, like DMI, DMC of the Accession and Candidate countries was found to be significantly more influenced by non-renewable material consumption than development of the EU. However, for the reasons discussed before, also the contribution of renewables to overall changes of material consumption has to be analyzed under a critical view.
Further decomposition analysis was performed in detail (as far as data were available) to identify the major driving constituents of these changes of DMC over time. The results are:

Brazil: DMC increase mainly caused by constructions, and consumption of agricultural products;

EU-15: decrease of DMC as a result of reduction of energy consumption (lignite and hard coal), partly compensated by increased consumption of agricultural products and forestry products;

Austria: DMC increase mainly caused by domestic constructions;

Belgium and Luxembourg: DMC increase mainly caused by constructions (stones) and agricultural products, partly compensated by reduced energy consumption of fossils;

Denmark: DMC increase mainly caused by energy consumption of fossil fuels (oil, gas);

Finland: DMC increase mainly caused by forestry and agricultural products, and energy consumption of fossil fuels, and by constructions;

France: decrease of DMC as a result of reduced energy consumption of fossil fuels (coal, gas), metals and industrial minerals, partly compensated by increased DMC of agricultural products;

Germany: decrease of DMC mainly due to energy consumption of fossil fuels (lignite and hard coal), partly compensated by increase due to constructions;

Greece: DMC increase mainly caused by energy consumption by lignite;

Ireland: DMC increase mainly caused by domestic constructions;

Italy: analysis should include data for 1998 which are available only at ISTAT;

Netherlands: DMC increase mainly caused by domestic constructions, indicating that high biomass demand from imports was mainly for export;

Portugal: DMC increase mainly caused by domestic constructions;

Spain: DMC increase mainly caused by domestic constructions;

Sweden: DMC increase mainly caused by forestry and agricultural products, and energy consumption of fossil fuels;

UK: decrease of DMC mainly due to reduced hard coal consumption and constructions;
West-Germany: DMC increase mainly caused by constructions and by energy consumption of fossils;

AC-10: DMC increase mainly caused by forestry products and industrial minerals, partly compensated by reduced energy consumption of fossils;

Cyprus: DMC increase mainly caused by constructions, and energy consumption of fossils;

Czech Republic: decrease of DMC mainly due to energy consumption of fossils;

Estonia: decrease of DMC mainly due to energy consumption of fossils;

Hungary: DMC increase mainly caused by constructions;

Latvia: decrease of DMC mainly caused by forestry products, and reduced energy consumption of fossil fuels;

Lithuania: decrease of DMC mainly caused by constructions, and reduced energy consumption of fossil fuels;

Malta: DMC increase mainly caused by domestic industrial minerals consumption;

Poland: DMC increase mainly caused by constructions, partly compensated by reduced energy consumption of fossil fuels;

Slovakia: decrease of DMC mainly caused by constructions, partly compensated by increased energy consumption of fossil fuels;

Slovenia: DMC increase mainly caused by constructions;

AC-12: DMC stabilized as a result of increased constructions and agricultural products, compensated by reduced energy consumption of fossil fuels;

Bulgaria: DMC stabilized as a result of increased constructions, compensated by reduced energy consumption of fossil fuels;

Romania: decrease of DMC mainly due to energy consumption of fossil fuels;

AC-14: DMC increase mainly due to increased consumption of forestry products, constructions and industrial minerals, partly compensated by reduced energy consumption of fossil fuels;

Croatia: DMC increase mainly caused by constructions;

Turkey: DMC increase mainly caused by constructions, agricultural products, and energy consumption of fossil fuels;
Iceland: stabilization of DMC as a result of increased constructions, and reduced consumption of agricultural products;

Norway: DMC increase mainly caused by consumption of manufactured products not clearly allocatable to fossil fuels, minerals or biomass.

This analysis thus provides the basis for identifying priority areas to be addressed by policy in order to proceed towards sustainable domestic direct resource consumption. However, in contrast to DMI, direct resource management related to DMC is of limited influence in those economies that are characterized by low shares of DMC and DMI (especially Norway), because a large part of the direct material resource requirements cannot be addressed. It shows significantly different patterns for priority areas as follows.

In general, 28 of 38 economies showed a similar trend of DMC as compared with DMI. Of the remaining 10 economies with different DMC and DMI trends, 3 economies, i.e. the Netherlands, Latvia and Slovakia, had even reduced their DMC whereas their DMI had increased over the same period. For these economies, materials management aiming only at reducing DMC would thus have only limited effect on the reduction of their direct material requirement. This shows that DMC may have limited capability as an indicator for materials management, and should not be used as sole indicator in this respect. For another seven economies the trends of DMC and DMI were also different, i.e. for the EU-15 (DMI constant, DMC decreased), France (DMI constant, DMC decreased), the UK (DMI constant, DMC decreased), Estonia (DMI constant, DMC decreased), Lithuania (DMI constant, DMC decreased), AC-12 (DMI increased, DMC constant), and Bulgaria (DMI increased, DMC constant).

Domestic constructions and consumption of agricultural products have to be addressed in Brazil. It might be worth studying in how far basic changes of housing and nutrition patterns, as well as development of infrastructures may have contributed to the increase of DMC (absolute as well as per capita) in these areas.

For the EU-15 and its Member States it can be clearly seen that mostly a combination of the domestic consumption of fossil fuels, construction minerals, and agricultural products induced the overall changes of DMC. Constructions mostly contributed to increases of DMC (except in the Netherlands and in the UK), the same holds for agricultural products (except in EU-15 and France). The role of fossil fuels consumption is more diverse, in five Member States (Belgium and Luxembourg, France, Germany, and the UK) and in the EU-15 it contributed to
reduce DMC, whereas in 5 Member States (Denmark, Finland, Greece, Portugal, and Sweden) fossil fuels consumption contributed to increase DMC.

The situation in the Accession and Candidate Countries of the EU is somehow similar to the EU-15 and its Member States. Mostly construction minerals and fossil fuels led to changes of DMC in AC whereas agricultural products played a significant role only in AC-12 and Turkey. In the AC, domestic consumption of forest products and industrial minerals induced changes of DMC in more economies than consumption of agricultural products did. Constructions were, however, the most important inducer of increasing DMC in most of the economies of AC-14. Planning of infrastructure and housing development in the AC-14, thus, appears as the priority area for managing direct material consumption. The role of fossil fuels for the AC is not as diverse as described for the EU and its Member States. In eleven economies of AC-14, domestic fossil fuels consumption had decreased during the 1990s, and in only two economies (Cyprus and Turkey) it had contributed to increase DMC.

In Iceland, reduction of DMC could be fostered by reducing material intensive constructions. The increase of DMC in Norway requires further detailed analysis to figure out which compound products deriving from net imports are responsible for the increase of domestic direct material consumption.

As discussed for DMI, the analysis for changes of DMC should be considered as providing incomplete information only. It should be supplemented by inclusion of the hidden flows of domestic extraction or harvest and of the indirect or hidden flows of imports and exports, i.e. the Total Material Consumption (TMC). Only TMC allows comprehensive analysis for major implications and the effects of driving changes on the overall material consumption of an economy on the global scale. This should be subject in another study. So far, TMC data are scarce and development of internationally comparable TMC accounts should be fostered by Eurostat and DG Environment, as well as by national statistical offices and environmental institutions.
Table 29: Major components of DMC and their contributions to changes over time periods studied (for notes see Table 29).

<table>
<thead>
<tr>
<th>Time period</th>
<th>DMC major components latest year (% absolute)</th>
<th>Contributions to overall change during time period (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fossil fuels</td>
<td>Minerals</td>
</tr>
<tr>
<td>Non-Europe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>1975-1991</td>
<td>N.A.</td>
</tr>
<tr>
<td>Bolivia</td>
<td>1995</td>
<td>N.A.</td>
</tr>
<tr>
<td>Brazil</td>
<td>1975-1995</td>
<td>4%</td>
</tr>
<tr>
<td>Egypt</td>
<td>1995</td>
<td>N.A.</td>
</tr>
<tr>
<td>Japan</td>
<td>1975-1996</td>
<td>N.A.</td>
</tr>
<tr>
<td>USA</td>
<td>1991</td>
<td>36%</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1995</td>
<td>N.A.</td>
</tr>
<tr>
<td>European Union (15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europe</td>
<td>1980-1997</td>
<td>21%</td>
</tr>
<tr>
<td>Austria</td>
<td>1960-2000</td>
<td>16%</td>
</tr>
<tr>
<td>Belgium and Luxembourg</td>
<td>1980-1997</td>
<td>23%</td>
</tr>
<tr>
<td>Denmark</td>
<td>1980-1997</td>
<td>21%</td>
</tr>
<tr>
<td>Finland</td>
<td>1970-1999</td>
<td>12%</td>
</tr>
<tr>
<td>France</td>
<td>1980-1997</td>
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<td>Germany</td>
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<tr>
<td>Greece</td>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>Netherlands</td>
<td>1975-1993</td>
<td>31%</td>
</tr>
<tr>
<td>Portugal</td>
<td>1990-2000</td>
<td>13%</td>
</tr>
<tr>
<td>Spain</td>
<td>1980-1997</td>
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</tr>
<tr>
<td>Sweden</td>
<td>1980-1997</td>
<td>9%</td>
</tr>
<tr>
<td>UK</td>
<td>1970-1999</td>
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</tr>
<tr>
<td>West-Germany</td>
<td>1960-1990</td>
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<td>EU Accession 2004</td>
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<tr>
<td>AC-10</td>
<td>1992-2000</td>
<td>32%</td>
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<td>Cyprus</td>
<td>1992-2000</td>
<td>13%</td>
</tr>
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<td>33%</td>
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<td>Latvia</td>
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</tr>
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<td>Malta</td>
<td>1992-2000</td>
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<tr>
<td>Poland</td>
<td>1992-2000</td>
<td>33%</td>
</tr>
<tr>
<td>Slovak</td>
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<tr>
<td>Bulgaria</td>
<td>1992-2000</td>
<td>33%</td>
</tr>
<tr>
<td>Romania</td>
<td>1992-2000</td>
<td>23%</td>
</tr>
<tr>
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<td>AC-14</td>
<td>1992-2000</td>
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<td>1992-2000</td>
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</tr>
<tr>
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</tr>
<tr>
<td>Norway</td>
<td>1992-2000</td>
<td>36%</td>
</tr>
</tbody>
</table>

Table 29: Major components of DMC and their contributions to changes over time periods studied (for notes see Table 29).
Table 30: International data availability for TMR

<table>
<thead>
<tr>
<th>Source</th>
<th>Time period</th>
<th>5 major material groups available</th>
<th>Soil erosion included</th>
<th>Comments on sources and differences</th>
</tr>
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<td><strong>Non-Europe</strong></td>
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<td>China</td>
<td>Chen and Qiao 2000</td>
<td>1990-1996</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>European Union (15)</td>
<td>WI - this study</td>
<td>1980-1997</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Finland</td>
<td>Univ.Oulu</td>
<td>1970-1999</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Germany</td>
<td>WI</td>
<td>1991-2000</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Italy</td>
<td>Stat.Italy</td>
<td>1980-1998</td>
<td>NO</td>
<td>NO</td>
</tr>
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<td>Adriaanse et al. 1997</td>
<td>1975-1993</td>
<td>YES</td>
<td>YES</td>
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<td>work in progress</td>
<td>YES</td>
<td>YES</td>
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<td>Spain (*)</td>
<td>Stat.Spain</td>
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<td>UK</td>
<td>WI</td>
<td>1970-1999</td>
<td>YES</td>
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<td>West-Germany</td>
<td>WI</td>
<td>1960-1990</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

**EU Accession 2004**
breakdown by major groups not shown in Scasny et al. 2003; indirect flows of foreign trade incomplete because only coefficients of WI-MI-Werte database used which lacks many coefficients contained in economy-wide database of WI, especially for biotic materials

basic data for DMI require comparison with this study's results for Hungary, and most probably need to be updated, therefore DMI data were taken from this study and indirect flows from Hammer 2002; basis of hidden flow coefficients requires also detailed comparison with WI database

Notes:
(1) 5 major material groups are fossil fuels, minerals, biomass, other imported compound products not attributable to one of the other three specific material groups, earth excavation and dredging.
(2) The sixth TMR component, soil erosion associated with agricultural (and forestry) biomass requirements, has been characterized in the Eurostat Guide as memorandum item, erosion is, however, included in this study where data were available.

Sources:
WI: Bringezu and Schütz 2001a,b,c; Schütz 2003; data for EU-15 updated by this study
Univ.Oulu: Mäenpää et al. 2000
Stat.Italy: Barbiero et al. 2003
SERI: Hammer 2002
Therefore, TMR Spain in this study is based on Statistics Spain only.
Table 31 gives a summary of TMR data in the format described before. Among the total of 15 economies studied (14 countries plus EU-15), the absolute volume of TMR in the latest year of the period for which data were available was highest for China, followed by the USA, the EU, Germany and Japan. Contrary, Hungary, Denmark, Finland, the Czech Republic and the Netherlands had the lowest TMR in absolute terms. The highest average annual increase of TMR was observed also for China (at 8% p.a. from 1990 to 1996), which deserves special attention because of the high absolute level of China’s total material requirements. Next ranks Spain at 4% increase of TMR per year between 1996 and 2000. Poland and Hungary both increased their TMR at 3% per year on the average between 1992 and 1997, respectively 1993 to 1997. Also all the other economies had increased their TMR with the exceptions of Germany and the Czech Republic which are the only two countries that achieved absolute reduction of TMR over the periods studied. TMR of Germany declined by 7% in total from 1991 to 2000, TMR of the Czech Republic even by one third from 1990 to 2000. TMR of the EU-15 had increased only slightly by 4% in total from 1980 to 1997, similar to TMR of the U.S. which increased by only 3% from 1975 to 1994.

On a per capita basis, the total material requirements show a different distribution (Table 31). Here, Finland leads the top five with 99 tons per capita in 1999, followed by USA (86 t/cap in 1994), Germany (72 t/cap in 2000), Denmark (70 t/cap in 1997) and the Netherlands (67 t/cap in 1993). The high absolute TMR of China corresponds to a TMR per capita of 38 t/cap in 1996. A lower TMR per capita was found for Poland and Hungary (about 32 t/cap each in 1997). TMR per capita was also relatively low for Italy (39 t/cap in 1998), for the UK (44 t/cap in 1999), and for Japan (45 t/cap in 1994). TMR of the EU-15 ranged in the midfield at about 51 tons per capita in 1997. Like for absolute TMR, also TMR per capita had increased relatively most in China at 6% per year on the average from 1990 to 1996. Similarly, high absolute TMR as well as per capita increases of TMR were found especially for Spain, Hungary, Poland, Denmark and Finland. Among the 15 economies studied, only the Czech Republic, the U.S., and Germany had achieved significant decreases of their TMR per capita over the periods studied. TMR per capita of the EU-15 had remained rather constant from 1980 to 1997.

The share of foreign total material requirements of TMR was highest in the Netherlands, Italy, Japan, and Denmark. These four countries had sourced most of their total material requirement in other economies, for the Netherlands and Italy even about two third. All other 11 economies relied more or less predominantly on domestic total material resources, the EU-15 by 59% in 1997. China’s TMR in 1996 was almost exclusively based on domestic
resources (by 99%), and also the U.S. required only 7% of its TMR in 1994 from abroad.

Moderate foreign contributions to TMR were found for Spain (20%), Hungary (21%), Poland (23%), and the Czech Republic (26%).

With the exceptions of China, USA, and Hungary, the share of foreign material requirements was significantly higher for TMR than for DMI in most of the economies reporting on TMR (n=15). This underlines the statement made before, that TMR has to be considered in order to derive more representative information on the distribution of material requirements between domestic and foreign sources.

Most of the economies studied had increased their shares of imports of TMR over the observation periods, indicating the increasing globalization in terms of accelerated foreign trade especially during the 1990s (see also chapter 3). The only country that had decreased its foreign TMR share was Spain (factor 0.8 from 1996 to 2000). West Germany and Hungary had rather stabilized their foreign TMR share over the reporting periods. Most pronounced average annual increases of this ratio were found for Poland (factor 0.38 p.a.), China (0.37), and Hungary (0.25). Thus, especially newly industrializing economies (NIC) got increasingly involved in foreign trade after transition of their economies during the 1990s. The high increase of foreign TMR of China must be seen under the aspect that the absolute share of foreign TMR is very low at 1%. However, if the rate of increase will continue, i.e. a doubling in 5 years, China will increasingly put pressure on global material resources. Also the EU-15 had increased its foreign TMR share from 1980 to 1997 by 1.3 times whereas its overall TMR had remained almost constant, indicating increasing shift of environmental pressures to foreign countries. This will be analyzed in detail in chapter 3.

### Table 31: International data comparison for TMR (for notes see Table 30).

<table>
<thead>
<tr>
<th>Time period</th>
<th>TMR absolute</th>
<th>Change over period in %</th>
<th>Average change per year in %</th>
<th>Imports share of TMR</th>
<th>In-/Decrease of imports share over period</th>
<th>Average in-/decrease of imports share per year</th>
<th>TMR per capita</th>
<th>Change over period in %</th>
<th>Average change per year in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Europe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>1990-1996</td>
<td>47272</td>
<td>45%</td>
<td>8%</td>
<td>1%</td>
<td>2,2</td>
<td>0,37</td>
<td>38</td>
<td>36%</td>
</tr>
<tr>
<td>Japan</td>
<td>1975-1994</td>
<td>5567</td>
<td>35%</td>
<td>2%</td>
<td>56%</td>
<td>1,1</td>
<td>0,06</td>
<td>45</td>
<td>20%</td>
</tr>
<tr>
<td>USA</td>
<td>1975-1994</td>
<td>22432</td>
<td>3%</td>
<td>0%</td>
<td>7%</td>
<td>1,6</td>
<td>0,08</td>
<td>86</td>
<td>-13%</td>
</tr>
<tr>
<td>European Union (15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>1981,1990,1997</td>
<td>369</td>
<td>31%</td>
<td>2%</td>
<td>53%</td>
<td>1,1</td>
<td>0,07</td>
<td>70</td>
<td>28%</td>
</tr>
<tr>
<td>Finland</td>
<td>1970-1999</td>
<td>506</td>
<td>64%</td>
<td>2%</td>
<td>47%</td>
<td>1,8</td>
<td>0,06</td>
<td>99</td>
<td>47%</td>
</tr>
<tr>
<td>Germany</td>
<td>1991-2000</td>
<td>5952</td>
<td>7%</td>
<td>1%</td>
<td>40%</td>
<td>1,3</td>
<td>0,14</td>
<td>72</td>
<td>-10%</td>
</tr>
<tr>
<td>Italy</td>
<td>1980-1998</td>
<td>2253</td>
<td>30%</td>
<td>2%</td>
<td>66%</td>
<td>1,3</td>
<td>0,07</td>
<td>39</td>
<td>27%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1975-1993</td>
<td>1018</td>
<td>23%</td>
<td>1%</td>
<td>70%</td>
<td>1,2</td>
<td>0,07</td>
<td>67</td>
<td>10%</td>
</tr>
<tr>
<td>Spain</td>
<td>1996-2000</td>
<td>1892</td>
<td>18%</td>
<td>4%</td>
<td>20%</td>
<td>0,8</td>
<td>0,20</td>
<td>48</td>
<td>17%</td>
</tr>
<tr>
<td>UK</td>
<td>1970-1999</td>
<td>2594</td>
<td>33%</td>
<td>1%</td>
<td>45%</td>
<td>1,3</td>
<td>0,05</td>
<td>44</td>
<td>25%</td>
</tr>
<tr>
<td>West-Germany</td>
<td>1980-1990</td>
<td>4387</td>
<td>60%</td>
<td>2%</td>
<td>47%</td>
<td>1,0</td>
<td>0,03</td>
<td>69</td>
<td>40%</td>
</tr>
<tr>
<td>EU Accession 2004</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1990-2000</td>
<td>668</td>
<td>-32%</td>
<td>-3%</td>
<td>26%</td>
<td>1,4</td>
<td>0,14</td>
<td>65</td>
<td>-32%</td>
</tr>
<tr>
<td>Hungary</td>
<td>1993-1997</td>
<td>322</td>
<td>12%</td>
<td>3%</td>
<td>21%</td>
<td>1,0</td>
<td>0,25</td>
<td>31,8</td>
<td>13,7%</td>
</tr>
<tr>
<td>Poland</td>
<td>1992,1995,1997</td>
<td>1226</td>
<td>15%</td>
<td>3%</td>
<td>23%</td>
<td>1,9</td>
<td>0,38</td>
<td>31,7</td>
<td>14,2%</td>
</tr>
</tbody>
</table>

93
Among the 15 economies studied for the contribution of the six major components to TMR, this information was not available by the relevant publications for Italy and the Czech Republic. Among the remaining 13 economies, three did not report on soil erosion (Denmark, Spain, Hungary), and Spain did not report on excavation as well. So, the comparison of major contributors is somehow limited but still comprehensive for the remaining 9 of 15 economies. Among the 13 economies reporting on components of TMR, minerals were found to be the single most dominant constituent of TMR in 5 economies (Japan, EU-15, Finland, the UK, and West Germany), (Table 32). Fossil fuels and minerals dominated TMR in another 3 economies (Denmark, Germany, Poland), and fossils as single most important TMR component was found in the U.S. and in Hungary only. TMR of China was dominated by excavation due to huge infrastructure developments in the 1990s. Fossils and erosion determined largely the TMR of the Netherlands, minerals and biomass the TMR of Spain. Biomass or other products were no single most important contributors to TMR in the economies studied.

The total contribution of non-renewable materials (fossil fuels, minerals, excavation, and erosion) to TMR ranged from 72% in Finland to 97% in China, a much more narrow range than observed for DMI and DMC, indicating that the relevance of non-renewables for resource use may be severely neglected by relying on direct material flow indicators only. The EU-15 required 87% of its TMR by non-renewables, also a significantly higher share than for DMI (66%) and DMC (66%), indicating that total non-renewable material use in the EU is associated with overproportional shares of hidden or indirect flows. In Japan (93%) and in the U.S. (91%) the non-renewables shares of TMR were even higher than in the EU. Thus, all economies studied were found to have a relatively high share of total non-renewable materials and require substantial efforts in order to proceed towards more sustainable total material resource use on the global scale. This result further puts into perspective the findings for DMI and DMC with regard to the higher share of renewables of those indicators; in addition, accounting only for direct use of renewable materials (biomass) does not consider side effects of agricultural production leading to considerable losses by soil erosion and, thus, (at current rates) irreversible loss of productive land, an example for an unsustainable mode of production.

Analysis of the contribution of the six major TMR components to the overall change of TMR over the time periods studied showed that also minerals and a combination of minerals and fossils contributed most to increases of TMR (Table 32). With the exceptions of Germany and
Czech Republic, all other economies studied, i.e. 13, had increased their TMR over the periods studied. The TMR of Germany had decreased from 1991 to 2000 because of reduced total material requirements for fossil fuels, and the same applies for the reduction of TMR of the Czech Republic.

In total, non-renewables (fossil fuels, minerals, excavation, and soil erosion) contributed by 74% to the overall change of TMR in Finland and in the Netherlands, and by 97% to TMR change in China, again a much more narrow range than observed for changes of DMI and DMC. Change of TMR of the EU-15 was by 92% caused by non-renewables, respective changes in Japan also by 92%, and in the U.S. by 91%.

Further decomposition analysis was performed in detail (as far as data were available) to identify the major drivers of these changes of TMR over time. The results are:

China: TMR increase mainly caused by domestic constructions;

Japan: TMR increase mainly caused by domestic construction industry, and fossils and minerals demand by imports;

USA: TMR increase mainly caused by domestic extraction industries (minerals, fossils);

EU-15: TMR increase mainly caused by metals industries demand by imports, and domestic construction industry;

Denmark: TMR increase mainly caused by domestic minerals extractions industries, and by metals industries by imports;

Finland: TMR increase mainly caused by metals industries by imports;

Germany: decrease of TMR mainly due to domestic extraction industry for lignite;

Netherlands: TMR increase mainly caused by demand by imports for biomass, fossils, and unspecified semi-manufactured products;

Spain: TMR increase mainly caused by domestic construction industry, and demand by imports for fossils and metals;

UK: TMR increase mainly caused by demand by imports for metals and fossils;

West-Germany: TMR increase mainly caused by domestic extraction industry for lignite, and demand by imports for metals and biomass;

Hungary: TMR increase mainly caused by domestic agriculture, construction industry, and fossils extraction;
Poland: TMR increase mainly caused by demand by imports for minerals, and domestic construction industry.

This analysis thus provides the basis for identifying the priority areas to be addressed by policy in order to proceed towards sustainable total material resource management. It shows significantly different patterns for priority areas as follows.

Domestic construction industries have to be addressed mainly in China, Japan, the EU, Spain, Poland and Hungary. In China and in Poland, excavations of earth for constructions are major points for action. In the other four economies, construction minerals industries have to be addressed mainly in this respect.

Other main actors to be addressed for reducing TMR are industries depending on imported metals, this is the case in the EU, Denmark, Finland, Spain and in the UK.

Further, the fossil fuels demand by imports represents a major field of action in Japan, the Netherlands, Spain and in the UK.

The analysis of driving forces for increasing TMR underlines clearly, as for DMI and DMC, the high relevance of domestic construction industries and fossil fuels demand. It points in addition to DMI and DMC to the increasing importance of metals manufacturing industries depending mainly of material resources in foreign countries. In this respect, especially the EU and its Member States are concerned. In order to strive for global sustainable development by reducing total material requirements and their environmental impacts, it is thus not sufficient to consider DMI and DMC only, but TMR has to be taken into account as well.
### Table 32: Major components of TMR and their contributions to changes over time periods studied (for notes see Table 30).

<table>
<thead>
<tr>
<th>Time period</th>
<th>TMR major components latest year (% absolute)</th>
<th>Contributions to overall change during time period (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fossil fuels</td>
<td>Minerals</td>
</tr>
<tr>
<td>Non-Europe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>1990-1996</td>
<td>32%</td>
</tr>
<tr>
<td>Japan</td>
<td>1975-1994</td>
<td>28%</td>
</tr>
<tr>
<td>USA</td>
<td>1975-1994</td>
<td>37%</td>
</tr>
<tr>
<td>European Union (15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>1981,1990,1997</td>
<td>32%</td>
</tr>
<tr>
<td>Finland</td>
<td>1970-1999</td>
<td>10%</td>
</tr>
<tr>
<td>Germany</td>
<td>1991-2000</td>
<td>40%</td>
</tr>
<tr>
<td>Italy</td>
<td>1980-1998</td>
<td>N.A.</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1975-1993</td>
<td>22%</td>
</tr>
<tr>
<td>Spain</td>
<td>1996-2000</td>
<td>21%</td>
</tr>
<tr>
<td>UK</td>
<td>1970-1999</td>
<td>31%</td>
</tr>
<tr>
<td>West-Germany</td>
<td>1960-1990</td>
<td>33%</td>
</tr>
<tr>
<td>European Union (15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1990-2000</td>
<td>N.A.</td>
</tr>
<tr>
<td>Hungary</td>
<td>1993-1997</td>
<td>58%</td>
</tr>
<tr>
<td>Poland</td>
<td>1992,1995,1997</td>
<td>40%</td>
</tr>
</tbody>
</table>

N.A. = data not available, respectively not given in publication (Italy, Czech Republic)
2.4. Material productivities of DMI, DMC and TMR by cross-country comparison.

The material productivities of the absolute values of DMI, DMC and TMR were analyzed in time series for the economies listed before, in order to evaluate in a comparative manner significant developments of GDP and material flows, and to identify reasons and drivers of changes. The relation of the development of GDP and material flows can be classified in general as follows:

1. over-proportional coupling (short: overcoupling): Material Flows grow faster than GDP;
2. direct coupling (short: coupling): Material Flows grow with the same rate as GDP;
3. relative decoupling: Material flows grow more or less with the GDP, or, Material Flows are constant irrespective of GDP;
4. absolute decoupling: Material Flows are decreasing with increasing GDP;

Besides, re-coupling events may occur during the observation period if material flows increase relatively to a decreasing or a constant trend before, and in line with increasing GDP. Further, irregular trends may occur which do not allow for clear attribution of the overall development to one of the general trends 1 to 4 as described above. The latter case, however, was so far not observed.

The relation of the material flow indicators DMI and TMR to economic growth was also studied by the Wuppertal Institute in international comparison for a couple of the economies analyzed in this study, though not for all (Bringezu et al. 2003b). This study was based on comprehensive regression analysis for the per capita values of DMI, TMR and GDP. It differs in so far from the analysis performed in this study which is based on absolute values of DMI, TMR and GDP. The results from both studies with regards to the general trends of the relation of DMI and TMR to GDP (for coupling, decoupling etc.) are, however, the same in most cases. There are only a few exceptions (4 for DMI out of 24 economies studied for comparison and 1 for TMR out of 12 economies compared) which will be pointed out and discussed in the following.

It may be argued whether absolute or per capita values of material resource use and GDP should be preferred for the analysis of their relation over time. Per capita values indicate specific material resource requirements for changing populations on an internationally normative basis. Absolute values indicate the absolute contribution of economies to global material resource requirements and related environmental pressures which allows ranking of
countries with respect to their individual contributions. Certainly, both approaches are important in their own rights and it depends on the target of the analysis which one is preferred, or if comparative analysis should be performed. In this study, the absolute values were chosen because analysis for per capita values had already been done (Bringezu et al 2003b) and could be used for comparative analysis of the results.

**Productivity of DMI**

The material productivity of DMI in the latest year of the periods studied was highest in Japan, followed by Germany, Austria, the UK, France, and the EU-15 (Table 33). Contrary, the lowest productivities of DMI were found in Estonia, Bulgaria, Cyprus, Latvia, Bolivia, and Egypt. The EU Accession and Candidate countries were in general characterized by relatively low DMI productivities. The same holds for the developing countries studied. Due to high absolute direct material requirements, also Iceland and Norway had relatively low DMI productivities as compared with the industrial economies of the EU-15, Japan and USA.

In most of the 40 economies studied, the productivity of DMI increased over the observation periods. Highest increase rates per year were found for China, Poland, Slovakia, Malta, and AC-10. The DMI productivity also increased in the EU-15 from 1980 to 1997 by factor 1.4, as it did in all Member States except in Denmark where it had remained constant from 1980 to 1997, and in Greece where it had decreased by factor 0.9 over the same period. Similarly, DMI productivity had decreased in Brazil (factor 0.9 from 1975 to 1995), in Bulgaria, and in Croatia (both also by factor 0.9 from 1992 to 2000). A constant DMI productivity over time was found in Australia, Denmark, Latvia, Lithuania, Slovenia, and Norway.

Most of the economies studied had a lower DMI productivity than the EU-15. However, relative to the GPD/DMI ratio of the EU-15, Japan had a 2.2 times higher DMI productivity in the same year, and also Austria, France, and Germany ranked above the DMI productivity of the EU as a whole. Contrary, especially Estonia, Cyprus, Bulgaria, Latvia, and Bolivia had significantly lower DMI productivities than the EU in the same year that ranged at about one tenth of GDP/DMI of the EU-15. Special attention has to be payed to the low DMI productivities of the Accession and Candidate Countries of the EU. In order to reach the same level as the EU, their DMI productivities would have to be increased by factor 5.2 for AC-10, factor 5.6 for AC-12, and factor 4.5 for AC-14, an enormous challenge for these (mostly) newly industrializing economies in the future. The challenge is especially high for Estonia, Cyprus, Bulgaria and Latvia which require an increase of DMI productivity by factors 17, 13, 12 and 10, respectively, to achieve the level of the EU-15. The best performance among the
Accession and Candidate countries was found for Malta which still would have to increase DMI productivity by factor 1.6 to reach the EU-15 level.

In most of the 40 economies studied, relative decoupling of DMI from GDP occurred over the periods studied, including the EU and most of its Member States, but also the Accession and Candidate countries of the EU in total. Absolute decoupling could be observed only in two economies, the Czech Republic and Romania. Coupling of DMI and GDP was found in Australia, Denmark, Latvia, Slovenia, Turkey, and Norway. Overcoupling of DMI relative to GDP was observed in Brazil, Greece, and Lithuania, and in Croatia over most of the period studied. These economies are even far from what might be called weak sustainability aiming at relative decoupling of DMI and GDP. Overcoupling may be seen as an alarm signal for development into the wrong direction.

On a per capita basis (Bringezu et al. 2003b), the results differ from this study (which is based on absolute values) for four economies: Norway, Denmark, Germany, and France. For Germany and France the per capita regression analysis resulted in an indication for absolute decoupling whereas the absolute values from this study indicate relative decoupling. The reason for the difference for Germany is that only the per capita DMI declined slightly from 1991 to 2000 whereas the absolute DMI had remained more or less constant and even increased slightly in 2000 as compared with 1991 (by 1%). The same holds for France where DMI had remained more or less constant whereas DMI per capita had declined by 8% from 1980 to 1997. For Norway, absolute values indicate rather overall coupling whereas per capita values indicate overcoupling. The difference is, however, not due to absolute versus per capita values. Overcoupling of DMI to GDP in Norway occurred only from 1992 to 1996 followed by relative decoupling from 1996 to 2000. For Denmark, per capita values indicate relative decoupling whereas absolute values indicate coupling. Again, the difference is not due to absolute versus per capita values. DMI and GDP in Denmark end up in 1997 at the same level of increase as compared with the initial values in 1980 which was interpreted as coupling in this study, although intermediate phases from 1980 to 1997 showed overcoupling as well as decoupling trends.

The reasons for changes of DMI over the reporting periods of the economies have been described before. The reasons for trends of coupling or decoupling of DMI from GDP can be characterized as follows:

Australia: GDP and DMI both increase linear;

Brazil: DMI increase over GDP increase during most of period and in total;
China: GDP increase over DMI increase throughout period;

Japan: GDP increase over DMI increase throughout period;

USA: GDP increase over DMI increase through most of period;

European Union (15): GDP increase over DMI increase almost throughout period;

Austria: GDP increase over DMI increase through most of period;

Belgium and Luxembourg: GDP vs. DMI increases fluctuating evenly between overcoupling and decoupling;

Denmark: GDP vs. DMI increases fluctuating evenly between overcoupling and decoupling;

Finland: GDP increase over DMI increase through most of period;

France: GDP increase over DMI increase through most of period;

Germany: GDP increase over DMI increase through most of period;

Greece: DMI increase over GDP increase through most of period;

Ireland: GDP increase over DMI increase through most of period;

Italy: GDP increase over DMI increase through most of period;

Netherlands: GDP increase over DMI increase through most of period;

Portugal: GDP increase over DMI increase through most of period and also at end of period 98-2000, however, DMI productivity of Portugal decreased from 1990 to 2000 by 12%;

Spain: GDP increase over DMI increase through most of period;

Sweden: GDP vs. DMI increases fluctuating evenly between overcoupling and decoupling;

UK: GDP increase over DMI increase through most of period;

West-Germany: GDP increase over DMI increase almost throughout period;

AC-10: GDP steady increase, DMI largely constant from 1993-2000;

Cyprus: GDP steady increase, DMI variations end at lower overall increase than GDP in 2000;

Czech Republic: DMI decreases from 90-92 and from 97-99 stronger than simultaneous GDP decreases; GDP increase 93-96 stronger than simultaneous DMI increase;
Estonia: GDP decrease 92-94 almost coupled with DMI decrease, steady GDP increase 94-2000 (except 98/99) at lower DMI increase until 1997 and rather constant level of DMI thereafter;

Hungary: GDP steady increase 94-2000, DMI largely constant 95-2000;

Latvia: GDP decreases 92-93 and 94-95, as well as GDP increase 95-2000 paralleled by similar DMI trend;

Lithuania: DMI about same level in 2000 as in 1992, but GDP lower in 2000 than in 1992;

Malta: GDP steady increase, DMI variations end at lower overall increase than GDP in 2000;

Poland: GDP steady increase, DMI at rather constant lower level 93-2000;

Slovakia: GDP steady increase, DMI at rather constant lower level 93-98 and at slightly lower level 99-2000;

Slovenia: GDP steady increase almost paralleled by DMI increase;

AC-12: GDP steady increase, DMI largely constant from 93-2000;

Bulgaria: GDP steady increase only 97-2000, DMI slightly declined 97-99 and slightly increased 99-2000;

Romania: GDP increase 92-96 and GDP decline 96-99 to same level in 2000 accompanied by largely similar trend of DMI but at generally lower annual changes;

AC-14: GDP rather steady increase paralleled by DMI increase until 96 then leveling off of DMI at level of 96 until 2000;

Croatia: DMI overrides GDP increase until 1996, then GDP increased stepwise until 2000 whereas DMI slightly decreased;

Turkey: GDP and DMI trends almost parallel 92-94, DMI increase 94-98 stronger than parallel GDP increase, 98-2000 DMI declined at overall GDP increase;

Iceland: steady GDP increase 92-2000 until 95 accompanied by absolute DMI decrease, then slight re-coupling occurred until 2000 to slightly higher level than DMI in 1992;

Norway: GDP steady increase 92-2000 accompanied by higher increase of DMI until 96, then levelling off of DMI occurred at level of 96 until 2000.

The analysis shows that considerable efforts are required to achieve further decoupling of DMI from GDP growth in almost all economies. To this end, targets should be considered with regards to the extent of increase of DMI productivity over a set future time period and in
relation to a target year in the past. For example, recognizing the high volumes of material flows attributable especially to constructions, agriculture and energy demand, representing significant causes of environmental pressures, the German government has set the target for increasing the raw material productivity (of non-renewable raw materials) by factor 2.5 until 2020 on the basis of 1993 (BMU 1998), in order to achieve economic growth at such low claim to the environment that ecological functions are not trespassed. This target is regularly monitored by the German Federal Environment Agency, based on data of the German Federal Statistical Office, as integral part of the so-called “environment barometer” (http://www.umweltbundesamt.de/dux-e/ro-inf.htm). Despite of obvious limitations of the indicator raw material productivity (renewable raw materials are not addressed although their production is commonly associated with environmental pressures as well, and hidden or indirect flows are also not addressed but they cause environmental burden as well as the extraction of raw materials, and especially the exclusion of indirect flows associated with imports neglects the fact that significantly more foreign resources are required than the consideration of imported commodities tells), this activity is certainly a useful step in order to proceed towards more sustainable material resource use in Germany. Consequently, based on targets for increasing the material resource productivity of the economy, strategies for increasing the DMI resource productivity, as well as resource productivities for DMC, TMR and TMC, have to be developed and integrated into policies for sustainable development. The European Commission’s recent approach “Towards a Thematic Strategy on the Sustainable Use of Natural Resources” (Commission of the European Union 2003b) is a promising first step towards this goal in the European Union. However, the results described before clearly indicate, that integration of the Accession countries will require enormous additional efforts.
### Table 33: Resource productivity of DMI.

<table>
<thead>
<tr>
<th>Time period</th>
<th>ECU per t</th>
<th>Change over period by factor</th>
<th>Average change per year by factor</th>
<th>Relative to EU-15 (1995)</th>
<th>Factor for increase to EU-15 productivity</th>
<th>Productivity trends</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-Europe</strong></td>
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<tr>
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<td>1005</td>
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<td>0,06</td>
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<td>Czech Republic</td>
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<td>5,6 absolute decoupling</td>
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<td>2,1 coupling</td>
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<td>AC-12</td>
<td>1992-2000</td>
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<td>1,2</td>
<td>0,16</td>
<td>0,2</td>
<td>5,6 relative decoupling</td>
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<tr>
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<td>0,15</td>
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<td>7,0 absolute decoupling</td>
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<td><strong>EU Candidates</strong></td>
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<td>AC-14</td>
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<td>4,5 relative decoupling</td>
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<tr>
<td>Croatia</td>
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<td>0,11</td>
<td>0,4</td>
<td>2,8 overcoupling 99-2000</td>
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<td><strong>NON-EU Europe</strong></td>
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<tr>
<td>Iceland</td>
<td>1992-2000</td>
<td>400</td>
<td>1,2</td>
<td>0,15</td>
<td>0,4</td>
<td>2,6 relative decoupling</td>
</tr>
<tr>
<td>Norway</td>
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<td>1,0</td>
<td>0,12</td>
<td>0,5</td>
<td>2,0 coupling</td>
</tr>
</tbody>
</table>

(**): DMI productivity of Portugal decreased from 1990 to 2000 by 12%  

### Productivity of DMC

The material productivity of DMC in the latest year of the periods studied was highest in Norway, followed by Japan, the Netherlands, Austria, Germany, the UK, and Belgium/Luxembourg (Table 34). Thus, in contrast to DMI productivities, those industrial countries evolve with high DMC productivity (Norway, the Netherlands, Belgium/Luxembourg) that are characterized by high shares of exports resulting from their high direct material inputs. Contrary, the lowest productivities of DMC were found in Estonia, Bulgaria, Cyprus, Egypt, Latvia, and Bolivia, the same countries that were also characterized by low DMI productivities, which indicates that exports played a minor role relative to DMI in these economies. The EU Accession and Candidate countries were in...
general characterized by relatively low DMC productivities, as it was the case for DMI productivity. The same holds for the developing countries studied. Due to high absolute domestic material consumption, also Iceland had a relatively low DMC productivity as compared with the industrial economies of the EU-15, Japan and USA. In most of the 38 economies studied, the productivity of DMC had increased over the observation periods. Highest increase rates per year were found for Norway, Slovakia, Estonia, Poland, and AC-10, a similar distribution as observed for DMI productivities. The DMC productivity also increased in the EU-15 from 1980 to 1997 by factor 1.4, as it did in all Member States except in Greece where it remained constant from 1980 to 1997. DMC productivity had decreased in Brazil (factor 0.9 from 1975 to 1995), in Bulgaria, and in Croatia (both also by factor 0.9 from 1992 to 2000). A constant DMC productivity over time was also found in Australia, Slovenia, and Turkey.

Most of the economies studied had a lower DMC productivity than the EU-15. However, relative to the GPD/DMC ratio of the EU-15, Japan (2.2 times) and Norway (2.0) had significantly higher DMC productivities in the same year, and also Belgium/Luxembourg, Denmark, France, Germany, the Netherlands, and the UK ranked above the DMC productivity of the EU as a whole. Contrary, especially Bolivia, Egypt, Cyprus, Estonia, Latvia, Lithuania, Bulgaria, and Romania had significantly lower DMC productivities than the EU in the same year that ranged at about one tenth of GDP/DMC of the EU-15. Special attention, as for DMI productivities, has to be payed to the low DMC productivities of the Accession and Candidate Countries of the EU. In order to reach the same level as the EU, their DMC productivities would have to be increased by factor 4.6 for AC-10, factor 5.1 for AC-12, and factor 4.1 for AC-14, an enormous challenge for these (mostly) newly industrializing economies in the future. The challenge is especially high for Estonia, Cyprus, Bulgaria and Latvia which require an increase of DMC productivity by factors 16, 13, 12 and 9, respectively, to achieve the level of the EU-15. The best performance among the Accession and Candidate countries was found for Malta which still would have to increase DMI productivity by factor 1.7 to reach the EU-15 level. The situation of the AC as regards DMC productivity is thus the same as found for DMI productivity, indicating that domestic consumption of (direct) materials is the dominating use of the direct material inputs in these economies.

In most of the 38 economies studied, relative decoupling of DMC from GDP occurred over the periods studied, including the EU and most of its Member States, but also the Accession and Candidate countries of the EU in total. In contrast to DMI, absolute decoupling of DMC
from GDP could be observed in more economies (i.e. 8 vs. 2 for DMI), in the Netherlands, the UK, the Czech Republic, Estonia, Latvia, Lithuania, Romania, and Norway. Coupling of DMC and GDP was found in Australia, Greece, Slovenia, Bulgaria, and Turkey. Overcoupling of DMC relative to GDP was observed in Brazil and in Croatia. These economies are even far from what might be called weak sustainability as regards their domestic (direct) material consumption aiming at relative decoupling of DMC and GDP. Overcoupling may be seen as an alarm signal for development into the wrong direction.

The reasons for changes of DMC over the reporting periods of the economies have been described before. The reasons for trends of coupling or decoupling of DMC from GDP can be characterized as follows:

Australia: GDP and DMC both increase almost linear;

Brazil: DMC over GDP change almost during entire period;

Japan: GDP increase over DMC increase almost throughout period;

European Union (15): GDP over DMC change throughout most of period;

Austria: GDP over DMC change through most of period;

Belgium and Luxembourg: GDP over DMC change through most of period;

Denmark: GDP vs. DMC increases fluctuating between overcoupling and decoupling;

Finland: GDP over DMC change throughout most of period;

France: GDP over DMC change throughout most of period;

Germany: GDP over DMC change through most of period;

Greece: DMC change varying between higher and lower than GDP changes;

Ireland: GDP over DMC change throughout most of period;

Italy: GDP over DMC change throughout most of period;

Netherlands: GDP increase while DMC fluctuates 77-97 at lower level than 75-76;

Portugal: GDP over DMC change throughout most of period and also at end of period 98-2000, however, DMC productivity of Portugal decreased from 1990 to 2000 by 13%;

Spain: GDP over DMC change throughout most of period;

Sweden: GDP over DMC change throughout most of period;

UK: GDP over DMC change throughout most of period;
West-Germany: GDP over DMC change since 1973 continuously;

AC-10: GDP steady increase, DMC largely constant 93-2000;

Cyprus: GDP steady increase, DMC variations end at lower overall increase than GDP in 2000;

Czech Republic: DMC decreases 90-94 and 97-99 stronger than simultaneous GDP changes;

Estonia: GDP decrease 92-94 almost coupled with DMI decrease, steady GDP increase 94-2000 (except 98/99) at lower DMC increase until 1997 and rather constant level thereafter;

Hungary: GDP steady increase 93-2000, DMC increase stronger 93-96, then largely constant 95-99, declines 99-2000;

Latvia: GDP decreases 92-93 and 94-95, as well as GDP increase 95-2000 paralleled by overall similar DMC trend though at high fluctuations;

Lithuania: GDP 98-2000 fluctuating around constant level, DMC strong decline 98-99 and in 2000;

Malta: GDP steady increase, DMC variations end at lower overall increase than GDP in 2000;

Poland: GDP steady increase, DMC at rather constant lower level 93-2000;

Slovakia: GDP steady increase, DMC at rather constant lower level 95-97 and declining 97-2000;

Slovenia: GDP steady increase almost paralleled by DMC increase

AC-12: GDP steady increase, DMC largely constant 93-2000;

Bulgaria: GDP steady increase only 97-2000 after strong decline 95-97 ends at lower level in 2000 than in 1992, DMC decline 95-99 and increase to 2000 to level of 1992;

Romania: GDP increase 92-96 and GDP decline 96-99 to same level in 2000 accompanied by largely similar trend of DMC but at generally lower annual changes;

AC-14: GDP rather steady increase paralleled by DMC increase until 96 then leveling off at level of 96 until 98 and slight decline until 2000;

Croatia: DMC overrides GDP increase until 1998, then GDP increase stepwise 99 to 2000 whereas DMC slightly decreases;

Turkey: GDP and DMC trends almost parallel 92-94, DMC increase 94-99 stronger than parallel GDP increase, 99-2000 DMC decline at GDP increase;
Iceland: steady GDP increase 92-2000 until 95 accompanied by absolute DMC decrease, then slight re-coupling until 2000 to slightly higher level as DMC 1992;

Norway: GDP steady increase 92-2000 accompanied by higher increase of DMC until 95, then DMC decline stepwise 96-2000.

The analysis shows that considerable efforts are required to achieve further decoupling of DMC from GDP growth in most of the economies studied, but considerably more economies than studied for DMI had even already achieved absolute decoupling of DMC from DMI. This requires in particular a strategy for sustainable consumption and production. An example for such a strategy is the recent “UK Government Framework for Sustainable Consumption and Production” (DEFRA 2003).

The comparison of DMI and DMC productivities revealed that economies with both high direct material use and high exports achieve of course significant better DMC than DMI productivity. This puts light on a necessary critical evaluation of productivity measures for economies. The authors conclude that DMC as the sole indicator for material productivity bears the risk that economies with high exports get overevaluated in so far as the environmental burden that they put on the global environment by requiring high amounts of direct material inputs needed to produce commodities for export thus gets out of sight. The recommendation rather has to be that a combination of productivity measures is needed, comprising DMI and DMC as well as TMR and TMC, to account for the comprehensive material resource requirement respectively consumption of an economy. Comparative analysis will then unveil to which extent an economy is based on export oriented economic growth, and in how far an economy is based on global material resource intensive production and consumption for achieving economic wealth.
Table 34: Resource productivity of DMC.

<table>
<thead>
<tr>
<th>Time period</th>
<th>GDP per DMC</th>
<th>Change over period by factor</th>
<th>Average change per year by factor</th>
<th>Relative to EU-15 (in 1995) (*)</th>
<th>Factor for increase to EU-15 productivity</th>
<th>Productivity trends</th>
</tr>
</thead>
<tbody>
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<td>1975-1991</td>
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<td>1.0</td>
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European Union (15)

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<th>Average change per year by factor</th>
<th>Relative to EU-15 (in 1995) (*)</th>
<th>Factor for increase to EU-15 productivity</th>
<th>Productivity trends</th>
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<td>1358</td>
<td>1.2</td>
<td>0.13</td>
<td>1.2</td>
<td>0.8</td>
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<tr>
<td>Greece</td>
<td>1980-1997</td>
<td>649</td>
<td>1.0</td>
<td>0.06</td>
<td>0.6</td>
<td>1.6</td>
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<tr>
<td>Ireland</td>
<td>1980-1997</td>
<td>412</td>
<td>2.1</td>
<td>0.12</td>
<td>0.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Italy</td>
<td>1980-1998</td>
<td>549</td>
<td>1.1</td>
<td>0.07</td>
<td>0.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1975-1997</td>
<td>1415</td>
<td>2.0</td>
<td>0.09</td>
<td>1.3</td>
<td>0.8</td>
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<tr>
<td>Portugal (**)</td>
<td>1980-2000</td>
<td>579</td>
<td>1.2</td>
<td>0.06</td>
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<td>Spain</td>
<td>1980-1997</td>
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<td>1.7</td>
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<td>Sweden</td>
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<tr>
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EU Accession 2004

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<tr>
<th>Time period</th>
<th>GDP per DMC</th>
<th>Change over period by factor</th>
<th>Average change per year by factor</th>
<th>Relative to EU-15 (in 1995) (*)</th>
<th>Factor for increase to EU-15 productivity</th>
<th>Productivity trends</th>
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</thead>
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<tr>
<td>AC-10</td>
<td>1992-2000</td>
<td>257</td>
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<td>0.16</td>
<td>0.2</td>
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</tr>
<tr>
<td>Cyprus</td>
<td>1992-2000</td>
<td>88</td>
<td>1.2</td>
<td>0.15</td>
<td>0.1</td>
<td>12.9</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1990-2000</td>
<td>223</td>
<td>1.6</td>
<td>0.16</td>
<td>0.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Estonia</td>
<td>1992-2000</td>
<td>76</td>
<td>1.4</td>
<td>0.17</td>
<td>0.1</td>
<td>15.9</td>
</tr>
<tr>
<td>Hungary</td>
<td>1992-2000</td>
<td>427</td>
<td>1.1</td>
<td>0.14</td>
<td>0.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Latvia</td>
<td>1992-2000</td>
<td>111</td>
<td>1.2</td>
<td>0.15</td>
<td>0.1</td>
<td>9.0</td>
</tr>
<tr>
<td>Lithuania</td>
<td>1992-2000</td>
<td>167</td>
<td>1.2</td>
<td>0.14</td>
<td>0.1</td>
<td>7.6</td>
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<tr>
<td>Malta</td>
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<td>601</td>
<td>1.3</td>
<td>0.16</td>
<td>0.6</td>
<td>1.7</td>
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<tr>
<td>Poland</td>
<td>1992-2000</td>
<td>248</td>
<td>1.4</td>
<td>0.17</td>
<td>0.2</td>
<td>4.9</td>
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<td>Slovenia</td>
<td>1992-2000</td>
<td>560</td>
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EU Accession 2007

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<th>Time period</th>
<th>GDP per DMC</th>
<th>Change over period by factor</th>
<th>Average change per year by factor</th>
<th>Relative to EU-15 (in 1995) (*)</th>
<th>Factor for increase to EU-15 productivity</th>
<th>Productivity trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-12</td>
<td>1992-2000</td>
<td>232</td>
<td>1.3</td>
<td>0.16</td>
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<td>5.1</td>
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<td>Bulgaria</td>
<td>1992-2000</td>
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<td>0.12</td>
<td>0.1</td>
<td>11.6</td>
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<tr>
<td>Romania</td>
<td>1992-2000</td>
<td>170</td>
<td>1.3</td>
<td>0.16</td>
<td>0.1</td>
<td>6.7</td>
</tr>
</tbody>
</table>

EU Candidates

<table>
<thead>
<tr>
<th>Time period</th>
<th>GDP per DMC</th>
<th>Change over period by factor</th>
<th>Average change per year by factor</th>
<th>Relative to EU-15 (in 1995) (*)</th>
<th>Factor for increase to EU-15 productivity</th>
<th>Productivity trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-14</td>
<td>1992-2000</td>
<td>280</td>
<td>1.2</td>
<td>0.16</td>
<td>0.2</td>
<td>4.1</td>
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<tr>
<td>Croatia</td>
<td>1992-2000</td>
<td>410</td>
<td>0.9</td>
<td>0.11</td>
<td>0.4</td>
<td>2.4</td>
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<tr>
<td>Turkey</td>
<td>1992-2000</td>
<td>432</td>
<td>1.0</td>
<td>0.13</td>
<td>0.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

NON-EU Europe

<table>
<thead>
<tr>
<th>Time period</th>
<th>GDP per DMC</th>
<th>Change over period by factor</th>
<th>Average change per year by factor</th>
<th>Relative to EU-15 (in 1995) (*)</th>
<th>Factor for increase to EU-15 productivity</th>
<th>Productivity trends</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iceland</td>
<td>1992-2000</td>
<td>435</td>
<td>1.3</td>
<td>0.16</td>
<td>0.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Norway</td>
<td>1992-2000</td>
<td>3636</td>
<td>1.8</td>
<td>0.22</td>
<td>2.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

(**): DMC productivity of Portugal decreased from 1990 to 2000 by 13%

Productivity of TMR

The material productivity of TMR in the latest year of the periods studied was highest in Japan, followed by Denmark, Italy, the UK, and the EU-15, of which Japan, the UK and the EU-15 achieve similar high ranking as for DMI productivity (Table 35). Contrary, the lowest productivities of TMR were found in China, the Czech Republic, Poland, Hungary, and Finland. So, the three EU Accession countries in 2004 studied were all characterized by relatively low TMR productivities. The same holds for the only developing country outside Europe studied, i.e. China. Due to high absolute total material requirements, also Finland had a relatively low TMR productivity as compared with the industrial economies of the EU-15 and Japan, whereas the U.S. had a significantly lower ranking for TMR than for DMI productivity. In most of the 15 economies studied, the productivity of TMR had increased over the observation periods. Highest increase rates per year were found for Poland, China,
the Czech Republic, and Germany. So, the first three economies characterized by low TMR productivities had at least achieved relatively high average annual increases of their TMR productivities. The TMR productivity had increased in the EU-15 from 1980 to 1997 by factor 1.4, at the same extent as DMI productivity. In all Member States of the EU studied TMR productivity had also increased except in Spain where it had remained constant from 1996 to 2000. Similarly, TMR productivity had remained constant in Hungary from 1993 to 2000.

Most of the economies studied had a lower TMR productivity than the EU-15. However, relative to the GPD/TMR ratio of the EU-15, Japan had a 2.1 times higher TMR productivity in the same year, and also Denmark, and Italy ranked above the TMR productivity of the EU as a whole. Contrary, especially China, the Czech Republic, Poland and Hungary had significantly lower TMR productivities than the EU in the same year that ranged from factor 0.03 for China to factor 0.31 for Hungary. Special attention has thus to be payed to the low TMR productivities of the three Accession Countries of the EU in 2004 studied here. In order to reach the same level as the EU, their TMR productivities would have to be increased by factor 6.5 for the Czech Republic, factor 4 for Poland, and factor 3.2 for Hungary, a similar enormous challenge for these newly industrializing economies in the future as found for DMI and DMC productivities. The challenge is even much higher for China which requires an increase of TMR productivity by factor 29 to achieve the level of the EU-15.

In most of the 15 economies studied, relative decoupling of TMR from GDP occurred over the periods studied, including the EU and most of its Member States, but also China, Japan, the U.S. and Poland. Absolute decoupling could be observed only in two economies, the Czech Republic and Germany. Coupling of TMR and GDP was found in Spain and Hungary. In contrast to DMI and DMC, overcoupling of TMR relative to GDP was not found among the 15 economies studied.

On a per capita basis (Bringezu et al. 2003b), the results differ from this study (which is based on absolute values) only for USA, for which the per capita regression analysis resulted in an indication for absolute decoupling whereas the absolute values from this study indicate relative decoupling. The reason for this difference is that only the per capita TMR of the U.S. declined from 1975 to 1994 whereas the absolute TMR had remained more or less constant. It is thus the same reason as found for DMI in Germany and France.
The reasons for changes of TMR over the reporting periods of the economies have been described before. The reasons for trends of coupling or decoupling of TMR from GDP can be characterized as follows:

China: GDP increase over TMR increase throughout period except 94-95;
Japan: GDP increase over TMR change almost throughout period;
USA: GDP increase at rather constant TMR throughout period;
European Union (15): GDP increase at rather constant TMR throughout period;
Denmark: GDP increase higher than TMR increase 90-97;
Finland: GDP increase over TMR increase during period;
Germany: GDP change over TMR change through most of period;
Italy: GDP increase over TMR increase through most of period;
Netherlands: GDP increase over TMR increase through most of period;
Spain: GDP increase at stepwise increase of TMR;
UK: GDP increase over TMR change through most of period;
West-Germany: GDP increase over TMR change through most of period;
Czech Republic: TMR decreases 90-92 and 97-99 stronger than simultaneous GDP decreases;
GDP increase 93-96 stronger than simultaneous TMR increase, GDP slight decline 96-99 accompanied by strong decline of TMR, GDP 99-2000 slightly up again to level of 96 whereas TMR further declines slightly;
Hungary: GDP steady increase 94-97, TMR increase higher until 96 and only lower 96-97;
Poland: GDP increase over TMR increase all over period.

The analysis shows that considerable efforts are required to achieve further decoupling of TMR from GDP growth in almost all economies studied. To this end, targets set for the increase of DMI productivity have to be extended in order to achieve reduction of environmental pressure on the global scale. In this respect, only the inclusion of hidden or indirect flows by TMR provides information on the extent of foreign total resource requirements. National sustainability strategies as well as the European Commission’s recent approach “Towards a Thematic Strategy on the Sustainable Use of Natural Resources” (Commission of the European Union 2003b) should consider the material productivity of TMR as well as the productivities of DMI, DMC and TMC as discussed before, in order to
consider major relevant aspects of material resource requirements for production and consumption.

Table 35: Resource productivity of TMR.

<table>
<thead>
<tr>
<th>Time period</th>
<th>GDP per TMR ECU per t</th>
<th>Change over period by year by factor</th>
<th>Relative to EU-15 (=1) in 1995 (*)</th>
<th>Factor for increase to EU-15 productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1990-1996 12</td>
<td>1,3</td>
<td>0,19</td>
<td>0,03</td>
</tr>
<tr>
<td>Japan</td>
<td>1975-1994 706</td>
<td>1,4</td>
<td>0,07</td>
<td>2,05</td>
</tr>
<tr>
<td>USA</td>
<td>1975-1994 246</td>
<td>1,7</td>
<td>0,08</td>
<td>0,71</td>
</tr>
<tr>
<td>European Union (15)</td>
<td>1980-1997 357</td>
<td>1,4</td>
<td>0,08</td>
<td>1,00</td>
</tr>
<tr>
<td>Denmark</td>
<td>1981,1990,1997 394</td>
<td>1,1</td>
<td>0,06</td>
<td>1,10</td>
</tr>
<tr>
<td>Finland</td>
<td>1970-1999 236</td>
<td>1,4</td>
<td>0,05</td>
<td>0,62</td>
</tr>
<tr>
<td>Germany</td>
<td>1991-2000 345</td>
<td>1,2</td>
<td>0,12</td>
<td>0,88</td>
</tr>
<tr>
<td>Italy</td>
<td>1980-1998 391</td>
<td>1,1</td>
<td>0,08</td>
<td>1,15</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1975-1993 295</td>
<td>1,3</td>
<td>0,07</td>
<td>0,83</td>
</tr>
<tr>
<td>Spain</td>
<td>1996-2000 285</td>
<td>1,0</td>
<td>0,20</td>
<td>0,82</td>
</tr>
<tr>
<td>UK</td>
<td>1970-1999 374</td>
<td>1,5</td>
<td>0,05</td>
<td>0,98</td>
</tr>
<tr>
<td>West Germany</td>
<td>1960-1990 309</td>
<td>1,6</td>
<td>0,05</td>
<td>0,99</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1990-2000 63</td>
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<td>0,13</td>
<td>0,15</td>
</tr>
<tr>
<td>Hungary</td>
<td>1993-1997 113</td>
<td>1,0</td>
<td>0,20</td>
<td>0,31</td>
</tr>
<tr>
<td>Poland</td>
<td>1992,1995,1997 90</td>
<td>1,2</td>
<td>0,19</td>
<td>0,25</td>
</tr>
</tbody>
</table>


3. Globalization and trade

The third part of the study investigates the international trade relations of the EU over time and by regions and national economies, in order to analyse environmental effects in relation to economic trends in the course of increasing globalization.

This objective is approached in three major steps:

1. Analysis of long time series of EC/EU imports and exports in physical and monetary terms, including indirect resource requirements in physical terms.
2. Analysis of these trade parameters of the EC/EU with respect to origins and destinations differentiated by economic regions, country groupings and single countries.
3. Analysis of land use for imports, exports and domestic consumption of agricultural commodities of the EU.

3.1. Analysis of long time series of EC/EU imports and exports in physical and monetary terms, including indirect resource requirements in physical terms.

For analysis of long-term trends 1976 to 2000 of the foreign trade of the EC/EU, a database of international trade flows to (imports) and from (exports) the EC/EU was elaborated from the EUROSTAT NIMEXE (1976 to 1987) and COMEXT (1988 to 2000) databases, in values (ECU/EURO) and in quantities (metric tonnes). EC/EU-imports and –exports data were
compiled on the level of 2-digits commodity chapters, which were then aggregated to 14 commodity groups as shown in table A3 in the annex. In a next step, these 14 commodity groups were further aggregated to 5 major material groups (see also table A3 in the annex) in order to achieve comparability with the major material flow categories of economy-wide MFA as outlined in the Eurostat Methodological Guide (Eurostat 2001).

The long time series of imports and exports 1976 to 2000 represent the economic structure of the EC and EU-15 during this period by Member States. This is due to data availability from the Eurostat COMEXT database. The trends of total values of imports and exports, in monetary as well as in physical units, show, that the extensions of the EC economic region from 1976 to the EU-15 in 1995 obviously did not lead to remarkable changes of the volume and trend of foreign trade. This is corroborated by estimates for the total values of physical imports and exports which extended the data for the EC to the level of EU-15 from 1980 to 2000 (Bringezu and Schütz 2001b, Eurostat 2002).

The estimation of the total resource requirements (TMR) including indirect flows (EUROSTAT Methodological Guide 2001) of imports and exports of the EC/EU was performed using the database of the Wuppertal Institute for indirect flows coefficients associated with traded commodities (see e.g. Bringezu and Schütz 2001a,b,c, DEFRA 2002, Schütz 2003). This coefficients database has been adopted by statistical offices to account for the global resource requirement – TMR - in official environmental reporting: in the United Kingdom (www.statistics.gov.uk, Bringezu and Schütz 2001c), Poland (Central Statistical Office Poland 1999), Denmark (Pedersen 2002), Finland (Muukkonen 2000), and Italy (Barbiero et al. 2003). Furthermore, TMR was accounted by research groups in several other countries including USA and Japan, an overview is found in Bringezu et al. 2003a.

**Imports and exports in relation to GDP and DMI**

Figures 1 and 2 show imports and exports in physical and monetary terms for the EC and EU from 1976 to 2000. The monetary commodity imports and exports both increased significantly from 1993 to 2000, a clear indication of increasing involvement of the EC/EU trade in the course of increasing globalization that was reported to be most expressed during the 1990s (Enquete Commission 2001). The increases of the monetary imports and exports – and to a lesser extent - also of the physical exports were clearly higher than respective developments of the whole economy – expressed as GDP and Direct Material Input (DMI = Imports plus domestic raw materials extraction). This can be interpreted as a clear evidence for a globalization effect.
Figure 1: Imports and exports of the EC/EU from 1976 to 2000 - absolute.


Figure 2: Imports and exports of the EC/EU from 1976 to 2000, and GDP and DMI - Index.

Index 1976 = 100


Sources: Eurostat Comext 2001 (Imports and Exports); Eurostat NewCronos (GDP); Bringezu and Schütz 2001b, Eurostat 2002 (DMI).
The composition of physical imports

The composition of physical imports of the EC/EU showed a remarkable constant structure during the entire observation period of 25 years. About three fourths of the physical EC/EU imports are raw materials. Among the 14 commodity groups, the dominance of minerals fuels is obvious, with a constantly high share of 54% to 63% of all commodities (Figure 3). Second range ores (and concentrates) with 10% to 16%. Also the commodity groups minerals excl. ores (3-4%) and wood (4-6%) represent raw materials or commodities with a low degree of manufacturing. These four commodity groups account for more than three fourths of the physical imports of the EC and EU.

From 1995 to 2000 the physical imports of the EU-15 increased by 13%. A major part of this increase (48%) was due to increased imports of mineral fuels, followed by wood (12%). Minerals excl. ores contributed only little to this increase (2%), and imports of ores even decreased in absolute terms from 1995 to 2000. Interestingly, the import of iron and steel semi-manufactured products increased during the same period by almost 11 million tonnes which contributed about 7% to the increase of the total of physical imports (all metallic commodities contributed even 17%). For metals a shift from raw materials imports to imports of higher manufacturing degrees has taken place during the high period of globalization.

Furthermore, also exports of metallic commodities increased as imports, and range at about the same level as well. But the average prices of exported metallic commodities are clearly higher than those of imports. Obviously the foreign trade of metallic products concerns different qualities – e.g. iron and steel products of lower value are imported by the EU (e.g. for construction purposes), but high value iron and steel products manufactured in the EU (e.g. special steel products) are exported. Similar situations can be observed for mineral fuels and chemicals.
The composition of physical exports

About two thirds of the physical EC/EU exports since 1981 are raw materials, a similar situation as for imports (however, the physical trade balance of raw materials shows a clear surplus of imports – see further below). Minerals fuels constitute – as for imports – the dominant commodity group with 23% to 34% of all commodities exports (Figure 4). Next range metallic products with shares between 16% and 26%, nutritional goods with 10% to 22%, minerals excl. ores with 7% to 13%, and chemicals with 8% to 11%. Also wooden products (2% to 8%) and mineral products (2% to 4%) hold notable shares of the total export of commodities. Thus, the composition of the physical export appears more complex than the one of imports, and commodity groups (at the 2-digits level of Nimexe and CN) whose individual share is less than 2% of total exports in tonnes, together account for 15% to 16% of all exports. Still, mainly raw materials and semi-manufactured products contribute most to the total amount of exports – the same as for imports.

From 1976 to 2000 physical exports increased by about 128%, from 1999 to 2000 stepwise by ca. 7%. This relative increase was even more than that of physical imports (plus 51%) during the same period. As for imports, mineral fuels contributed mainly (by 26%) to the increase of physical exports. Next range nutritional goods (22%), followed by wooden products (12%), and metallic products (11%).
Physical and monetary trade balances and prices

During the period 1976 bis 2000 the EC/EU constantly had a clear surplus of imported commodities in tonnes, the physical trade balance (PTB) ranged between 531 million and 1 billion tonnes with an increasing tendency (Table 36). Mineral fuels contributed most to this increasing surplus of imports (67% to 76%), followed by metals (10% bis 20%). The imbalance of imports and exports increased from 1976 to 2000 by 32%. Except for biomass, for which a declining trend of PTB is observed, the physical foreign trade balances of the major material groups all increased from 1976 to 2000.

The monetary trade balance\(^1\) (MTB) shows surpluses of exports between 1993 and 1998, and surpluses of imports from 1976 to 1992 (except 1986) and in 1999 and 2000 (Table 36). Over the entire period, the MTB of metals and other products shows surpluses for exports, surpluses are observed constantly for the MTB of biomass and mineral fuels, whereas the MTB of minerals varies between surpluses of imports and exports. The monetary balances amount to at most 22% of the total volumes of imports and exports (which are almost equal by numbers), they are therefore by far lower than the physical balances (up to 400% of the total amounts of exports).

\(^1\) In this study the monetary trade balance was defined as imports minus exports. This is in contrast to the usual definition of monetary trade balances (exports minus imports). The reason for the different approach in this study was to make monetary and physical trade balances directly comparable in order to avoid confusion about opposite meanings. Physical trade balances were derived as given in The Eurostat methodological guide.
Thus, the EC/EU constantly requested physically more materials by global trade than it provided to the rest of the world (not considering indirect flows at this point). Imported commodities were rather of low value and low manufacturing level, whereas exports were rather of high value and high manufacturing level.

Average prices for imports of the EC/EU rose from 1976 to 2000 from 0.2 to 0.7 ECU per kg (Table 37). Least expensive were mineral fuels at 0.08 to 0.18 ECU per kg. Most expensive were metals at up to 2.1 ECU per kg and other products.

Prices for exported commodities by the EC/EU increased on the average from 1976 to 2000 from 0.8 to 2.2 ECU per kg (Table 37). Also for exports, mineral fuels were cheapest at 0.09 to 0.25 ECU per kg. Metals were the most expensive material group for export at 1.7 to 6.4 ECU per kg.

The total price ratio of imports to exports was relatively constant at 0.2 to 0.3 over the whole period 1976 to 2000 (Table 38). Imports were always cheaper than exports as concerns the material groups metals, minerals and mineral fuels. Occasionally in between 1976 and 2000, biomass and other products were imported at higher average prices than those for exports.
Table 36: Physical and monetary trade balances of the EC and EU from 1976 to 2000.

<table>
<thead>
<tr>
<th>EC/EU</th>
<th>Physical Trade Balance</th>
<th>Monetary Trade Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million Tonnes</td>
<td>Billion ECU</td>
</tr>
<tr>
<td>Biomass</td>
<td>761 698 700 767 731 602 585 531 568 579 674 696 731 763 799 837 910 890 914 892 942 1006</td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>112 90 89 116 108 88 86 75 93 99 107 114 146 140 133 130 128 75 70 68 59 67 70 68</td>
<td></td>
</tr>
<tr>
<td>Minerals</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Mineral fuels</td>
<td>541 500 500 526 504 427 404 349 389 393 463 469 518 560 591 652 644 571 598 646 674 698 763 704</td>
<td></td>
</tr>
<tr>
<td>Other products</td>
<td>-6 1 9 17 21 16 18 14 13 18 35 38 -17 -11 -7 -9 -4 17 18 25 37 28 40 47 66</td>
<td></td>
</tr>
</tbody>
</table>


Table 37: Importprices and Exportprices of the EC and EU from 1976 to 2000.

<table>
<thead>
<tr>
<th>EC/EU</th>
<th>Imports ECU per kg</th>
<th>Exports ECU per kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>0.17 0.19 0.22 0.28 0.35 0.42 0.46 0.47 0.50 0.53 0.56 0.59 0.62 0.65 0.68 0.71 0.74 0.77 0.80 0.83 0.86 0.89 0.92 0.95</td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>0.24 0.29 0.31 0.41 0.41 0.48 0.56 0.65 0.70 0.76 0.81 0.91 1.01 1.05 1.11 1.13 1.13 1.13 1.13 1.13 1.13 1.13</td>
<td></td>
</tr>
<tr>
<td>Minerals</td>
<td>0.01 0.11 0.12 0.15 0.17 0.17 0.20 0.19 0.17 0.15 0.14 0.12 0.10 0.09 0.09 0.09 0.09 0.09 0.09 0.09 0.09 0.09</td>
<td></td>
</tr>
<tr>
<td>Mineral fuels</td>
<td>0.08 0.09 0.10 0.15 0.21 0.23 0.22 0.24 0.24 0.21 0.11 0.11 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.10 0.10</td>
<td></td>
</tr>
<tr>
<td>Other products</td>
<td>0.78 0.79 0.81 0.83 0.85 0.87 0.89 0.91 0.94 0.96 0.98 0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20 0.22</td>
<td></td>
</tr>
</tbody>
</table>

Table 38: Importprices divided by Exportprices of the EC and EU from 1976 to 2000.

<table>
<thead>
<tr>
<th>EC/EU</th>
<th>B,D,F,I,L,NL,DK,IRL,UK</th>
<th>plus GR</th>
<th>plus E,P</th>
<th>plus A,FIN,S</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EC-9</td>
<td>EC-10</td>
<td>EC-12</td>
<td>EU-15</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.2 0.2 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biomass</td>
<td>0.6 0.6 0.6 0.7 0.7 0.8 0.7 0.9 1.0 1.1 1.1 1.5 0.8 0.9 0.9 0.8 0.8 0.8 0.7 0.6 0.6 0.6 0.7 0.7 0.7 0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>0.1 0.2 0.2 0.2 0.2 0.2 0.2 0.3 0.3 0.3 0.2 0.2 0.2 0.2 0.2 0.3 0.3 0.4 0.3 0.3 0.3 0.3 0.3 0.3 0.3 0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minerals</td>
<td>0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.7 0.7 0.6 0.7 0.7 0.8 0.8 0.7 0.7 0.7 0.7 0.6 0.6 0.6 0.7 0.7 0.7 0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral fuels</td>
<td>0.9 0.9 0.9 0.8 0.8 0.9 0.9 0.9 0.8 0.8 0.8 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.6 0.6 0.7 0.7 0.7 0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other products</td>
<td>0.8 0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.5 0.4 0.4 0.4 0.4 1.1 1.1 1.1 0.7 0.7 0.7 0.7 0.6 0.6 0.6 0.6 0.6 0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total material requirements of imports**

The composition of the total material requirement (TMR) associated with imported commodities by the EC/EU showed a more complex picture than for absolute physical imports which were clearly dominated by mineral fuels (Figure 5, compare Figure 3). In 2000, the TMR of imported mineral fuels (25% of total TMR) ranked only second after the TMR of ores (29%), and also the TMR of metal products (19%) and that of mineral products (15%) contributed significantly to the total TMR of imports of the EC/EU. Thus, TMR reveals material resource requirements for commodities that are imported after relatively resource and waste intensive steps of processing and manufacturing leaving high amounts of unused extraction and processing wastes in the countries of origin.

From 1976 to 2000 the total material requirement (TMR) associated with imported commodities by the EC/EU almost doubled from 4.4 to 8.6 billion tonnes (Figure 5). Most of this increase was assigned with imported ores (45%), followed by mineral fuels (26%), metal products (18%) and mineral products (10%), the four commodity groups also contributing most to TMR in absolute terms. The pattern of total material resource requirements by imports of the EC/EU appears therefore rather conservative even over a period of 25 years, and the highly resource intensive demands even increased most, indicating negative development of the respective import dependent economic sectors in the EC/EU with regards to reducing their global resource requirements and associated environmental impacts.

The average ratio of TMR to absolute imports was 6:1 in 2000, so, every tonne of imported commodity leaves an equivalent of 5 tonnes indirect or hidden flows in the countries of origin. The highest ratio of TMR to absolute imports in 2000 was observed for mineral products (144:1), followed by metal products (20:1), and ores (17:1). The highest relative increase from 1976 to 2000 of this ratio of TMR to absolute imports was found for ores (almost 4 times), followed by mineral fuels (1.5 times). On the average, this TMR/imports ratio had increased 1.3 times from 1976 to 2000. So, mainly due to increasing specific total material resource requirements for ores and mineral fuels, imports of the EC/EU had become increasingly resource intensive over time. This is also the case for the most recent development in the EU-15 where the TMR/imports ratio rose from 5.6:1 to 6:1 from 1995 to 2000.
Total material requirements of exports

The composition of the total material requirement (TMR) associated with exported commodities by the EC/EU showed a similar picture as for absolute physical exports, with the most obvious exception that the TMR of mineral products increases its rank considerably over its rank among absolute exports (Figure 6, compare Figure 4). In 2000, the TMR of metal products contributed most to TMR of exports (31%), indicating that the high TMR for imported ores had been required by metal manufacturing sectors in the EU producing (also) commodities for exports. Next to metal products follow contributions of mineral products to TMR (20%), nutritional and related commodities (18%), and mineral fuels (14%). Thus, total material resource requirements for imported and exported commodities show a relatively similar picture as regards the focus on non-renewable materials. A major difference represents the relatively high contribution of nutritional commodities to the TMR of exports as opposed to imports, indicating the relative importance of agricultural and derived production in the EC/EU.

From 1976 to 2000 the total material requirement (TMR) associated with exported commodities by the EC/EU increased from 1.5 to 2.3 billion tonnes, but values fluctuated from an intermediate high of 2.4 billion tonnes in 1987 until 2000 between values of 1.7 billion tonnes in 1988 to a maximum of 2.6 billion tonnes in 1993 (Figure 6). So, in contrast
to imports, there is no clear trend for the TMR of exports by the EC/EU during the period 1987 to 2000. Still, all over the 25-years period, the four commodity groups mineral fuels, metal products, mineral products, and nutritional commodities dominate the TMR of exports, a similar conservative pattern as observed for the TMR of imports. It shows that the total material resource requirements of these highly resource intensive exporting sectors in the EC/EU hardly changed and overall exports of the EC/EU did not proceed towards a less material resource intensive development.

The average ratio of TMR to absolute exports was almost 16:1 in 2000, considerably more than that of imports (6:1). So, exported commodities of the EU required much more material resources than imports, leaving respective amounts of processing wastes and unused extraction within the EU. The highest ratio of TMR to absolute exports in 2000 was observed (as for imports) for mineral products (27:1), followed by ores (17:1), and rubber and -products (14:1). In contrast to imports, the ratio of TMR to absolute exports of the EC/EU had declined significantly from 1976 (42:1) to 2000 (16:1). This was mainly due to a decline of the TMR/exports ratio for mineral products (0.2 times), but also the ratios for nutritional goods (0.6 times) and mineral fuels (0.95 times) declined whereas the ratio for metal products had increased (1.2 times). Thus, in contrast to imports, exports of the EC/EU had become increasingly less resource intensive over time, a positive signal for a relatively more sustainable development of the exporting industries of the EC/EU. This is also the case for the most recent development in the EU-15 where the TMR/exports ratio declined from 17.6:1 to 15.8:1 from 1995 to 2000.

**Figure 6: TMR of physical exports of the EC and EU 1976 to 2000 by commodity groups.**

Sources: Database of the Wuppertal Institute; Eurostat Comext 2001.
Physical trade balances with and without indirect flows

The physical trade balance (imports minus exports) of the EC/EU was conducted comparatively with and without indirect or hidden flows of imports and exports.

From 1976 to 2000 the EC/EU had a clear and increasing surplus of physical imports in absolute terms of up to 1 billion tonnes (Figure 7). This surplus increases significantly for the indirect or hidden flows associated with imports and exports which reaches a maximum of 5.3 billion tonnes in 2000. The same results for the total material requirement (absolute amounts of imports minus exports, both inclusive their indirect or hidden flows) which went up to a maximum of 6.3 billion tonnes in 2000 – from about 3 billion tonnes during 1976 to 1987. This increase of the TMR of PTB occurred in two periods, from 1984-1989 and from 1994-2000, after a decline in between. Thus, the EC/EU required globally always and at increasing level more physical resources than it provided to the rest of the world. The inclusion of indirect or hidden flows shows that the net resource requirement which is not recorded by official foreign trade statistics is by three to five times higher than the mere amount of traded commodities.

Figure 7: Physical trade balance (PTB) excl. and incl. indirect flows: EC/EU 1976-2000.

Note: Physical trade balance = Imports minus Exports

Sources: Eurostat Comext 2001 and Database of the Wuppertal Institute.

Analysis of material groups of the physical trade balance (imports minus exports) reveals that net-supplies (DMI) of the EC/EU between 1976 and 2000 were dominated by fossil fuels and
metals and metal products (Table 39). The increases of these groups mainly led to the overall increase of net-imports. These two material groups also determined the global net resource requirement (TMR) and its increase from 1976 to 2000.

Table 39: Physical trade balance of the EC/EU 2000 by material groups and change vs. 1976.

<table>
<thead>
<tr>
<th>Material Group</th>
<th>DMI 2000 (Million Tonnes)</th>
<th>DMI: Change vs. 1976</th>
<th>TMR 2000 (Million Tonnes)</th>
<th>TMR: Change vs. 1976</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass from agriculture</td>
<td>25.4</td>
<td>-61%</td>
<td>245.7</td>
<td>-57%</td>
</tr>
<tr>
<td>Biomass from forestry</td>
<td>40.3</td>
<td>8%</td>
<td>40.3</td>
<td>-60%</td>
</tr>
<tr>
<td>Biomass from fishing/hunting</td>
<td>2.0</td>
<td>268%</td>
<td>2.6</td>
<td>270%</td>
</tr>
<tr>
<td>Fossil fuels</td>
<td>704.1</td>
<td>30%</td>
<td>1821.5</td>
<td>106%</td>
</tr>
<tr>
<td>Metals and products</td>
<td>146.1</td>
<td>30%</td>
<td>3829.1</td>
<td>194%</td>
</tr>
<tr>
<td>Minerals and products</td>
<td>22.7</td>
<td>121%</td>
<td>254.1</td>
<td>221%</td>
</tr>
<tr>
<td>Other products</td>
<td>65.8</td>
<td>-1.141%</td>
<td>65.8</td>
<td>-1.141%</td>
</tr>
<tr>
<td>SUM</td>
<td>1006.4</td>
<td>32%</td>
<td>6259.2</td>
<td>114%</td>
</tr>
<tr>
<td>Renewable materials</td>
<td>67.7</td>
<td>-35%</td>
<td>288.6</td>
<td>-57%</td>
</tr>
<tr>
<td>Non-renewable materials</td>
<td>872.9</td>
<td>32%</td>
<td>5904.8</td>
<td>161%</td>
</tr>
</tbody>
</table>

Sources: Eurostat Comext 2001 and Database of the Wuppertal Institute.

3.2. Analysis of foreign trade parameters of the EC/EU with respect to origins of imports and destinations of exports.

The regional distribution of the EU international trade flows, compiled as described in chapter 3.1, was analysed for the major origins of imports and destinations of exports with regard to economic regions (e.g. ASEAN, NAFTA, MERCOSUR), country groupings (e.g. low-income countries, least developed countries, severely indebted countries), geographical regions, and individual national economies. The variation of these regional distributions was investigated for the time period 1976 to 2000 covering significant development trends with regards to globalization (Enquete Commission 2001). The results for monetary data and physical data were compared and similarities or discrepancies between the development of economic and resource flows trends were analysed. Trends for the period 1976 to 2000 are expressed in the following text and tables mainly as percent changes of the values in 2000 (EU-15) with reference to values in 1976 (EC-9).

The grouping of countries was done on the basis of the Eurostat COMEXT foreign trade database using the area composition information. In addition, a couple of other information sources were used in a comparative and supplementary manner. The classification of countries by income classes (GDP per capita) was taken from the World Bank publications,
also the allocation of heavily indebted poor countries (HIPC) and classes of the indebtedness of economies. A list of developing countries was derived from a comparative analysis of listings of the UN (human development report, UNCTAD), the World Bank, and the OECD. Least developed countries (LDC) and countries belonging to economic groups (like OECD) were classified after the systematics of the UN (COMTRADE) and the WTO (Trade Statistics), or using information published on official websites of the respective organizations. Newly industrializing countries (NIC), also called emerging market economies (EME), were identified after publications of the German centre for political education and after “Börsenlexikon”. (stock exchange encyclopaedia). The allocation of countries to geographical regions was taken over from the WTO trade statistics. All these countries groupings are listed in detail in Tables A4 to A7 in the annex. Table A4 shows countries by income classes, severely indebted countries (SIC), and highly indebted poor countries (HIPC). Table A5 lists developing countries (DC), least developed countries (LDC), and newly industrializing countries (NIC) in Europe and outside Europe. Table A6 shows the allocation of countries to geographical regions after the WTO trade statistics 2001, slightly modified to distinguish Esat Asia and Oceania. And Table A7 informs about the member countries of economic groups studied in this report.

A problem coming up for analysis of foreign trade of the EU by regions is due to increasing data for the unspecified trade like secret countries, especially since 1992. This constitutes an increasing deficiency of the foreign trade statistics of Eurostat in tracing back these imports to the countries of origin and in obtaining meaningful distribution patterns among regions and country groupings. External users of the Comext database of Eurostat, like in this study, cannot solve this problem but they are confronted with increasing limitation of the interpretation of their analysis. This problem should be tackled by Eurostat to come back to complete coverage for specified regional distributions as it was the case for data during the 1970s and 1980s until 1991. For this study the limitation means that e.g. in 2000 (standing for the higher degrees of data deficiency) the following shares for the six major trade parameters could not be specifically allocated to countries or regions: 9% of the physical imports in metric tonnes, 3% of the TMR of imports, 4% of the value of imports in ECU, 7% of the physical exports in metric tonnes, 3% of the TMR of exports, 3% of the value of exports in ECU. So, results obtained for countries and regions in this study are still based on at least 91% of the total trade and are therefore considered to be interpretable in a meaningful way, although cross comparison of the six major trade parameters seems slightly limited by the different degrees of not allocated trade.
Uncertainty about the allocation of the TMR of imports and exports

The allocation of hidden or indirect flows, and thus of TMR, to regions and countries bears some uncertainties which limit the interpretation of the results. These uncertainties are due to feasibility reasons. In this study hidden or indirect flows of imports and exports by regions and countries were calculated by average coefficients for commodity groups at the 2-digits level of the Nimexe and CN classification of the Eurostat Comext foreign trade statistics. The resulting allocation to regions and countries may, however, result in severe distortions. E.g. if the average hidden flow coefficient for ores is high because of a high share of resource intensive ores like copper, also the imports of ores from a country exporting mainly less material intensive ores like iron ore carry an overestimated high TMR (and vice versa). This may result in somehow misleading descriptions of the real situation. To overcome this problem, the database for the allocation of hidden or indirect flows to regions and countries would have to be established on a much more disaggregated level of commodity groups than the 2-digits level in order to be able to attribute specific hidden flow coefficients for e.g. at least 20 to 30 different kinds of ores. This in turn would require an enormous investment in labour and time that could be impossibly done within the scope of the present study.

Results of this study for the TMR of imports and exports by regions and countries have therefore to be considered as preliminary and as being subject to further more detailed analysis. It may be assumed that limitation of the use of the results for allocation becomes less serious the higher the regional aggregation is, e.g. the total of all developing countries outside Europe comprises 160 countries, because high aggregation most probably leads to more representative values for the respective TMR. The allocation problem does not occur for the results concerning the TMR of imports and exports in total and by material or commodity groups (chapter 3.1) because these are based on specific hidden or indirect flow coefficients representing the detailed composition of these aggregated groups.

This allocation problem for TMR is comparable with problems resulting from input-output analysis at highly aggregated levels of economic sectors, and it should also be critically discussed in this respect.

Foreign trade by income classes and with indebted countries

Table 40 gives an overview of the six major parameters derived from international trade data (imports absolute, imports TMR, imports value, exports absolute, exports TMR, exports value), and derived six parameters (PTB absolute, PTB of TMR, MTB, imports price, exports price, ratio of imports price to exports price), for income classes as well as for severely
indebted countries (SIC) and highly indebted poor countries (HIPC) (for detailed countries listing see Table A4 in the annex). Data for the EU-15 in 2000 are given in absolute terms, and for each component the development from 1976 to 2000 is expressed as percent change. Thus, in comparison with values for total trade, relative shares of countries groupings to absolute values become obvious, as well as their specific development as opposed to the change of total trade from 1976 to 2000.

Absolute physical imports (in million tonnes) of the EU-15 in 2000 came mainly from middle income countries (lower and higher middle income countries together account for 59% of the total) and from high income OECD countries (23%). The EU-15 received only 7% of its physical imports from low income countries in 2000. Furthermore, compared with an increase by 51% of total trade, physical imports from low income countries increased only below average at 31% from 1976 to 2000. A similar situation shows for SIC (16% of imports and 35% increase) and for HIPC (3% of imports and zero % increase). This resulted in even (slightly) reduced relative contributions of poor and indebted countries to the sourcing of commodities by the EC/EU from abroad (LIC contributed 8% in 1976 and 7% in 2000, SIC 17% versus 16%, HIPC 4% versus 3%, respectively). Still, severely indebted countries contribute quite significantly (16%) to imports of the EU-15 in 2000 which may be due to their special efforts in reducing external debts by selling material resources on the global market.

This becomes more obvious looking at the TMR of imports: SIC countries, as well as HIPC countries and LIC countries, held a significantly higher share of the TMR of imports of the EU-15 in 2000 than of the absolute amounts of imported commodities. The relation is 24% of TMR of imports for SIC countries in 2000 vs. 16% for absolute imports, for LIC countries it is 11% for TMR versus 7% for absolute imports, and for HIPC it is 6% versus 3% respectively. These differences cannot be observed for middle income countries and high income OECD countries. The TMR of imports of especially SIC countries had increased from 1976 to 2000 above average (149% versus 96%). This shows that exports of poor and highly indebted countries to the EU had been associated with increasing total material resource requirements with associated environmental impacts. An impressive evidence for this hypothesis represents the development in Chile since 1973 (Giljum 2002). With increasing integration into the world market, Chile had exported between 1973 and 2000 increasing amounts of resource intensive commodities, especially copper ores and concentrates. Also a diversification of the Chilean economy by the expansion of fruit plantation, forestry and
fishery, mainly for exports, in the end only contributed to an expansion of resource intensive sectors.

The imbalance of imports of the EU with poor and indebted countries is further documented by comparison of the physical and monetary data. Whereas the imports from high income OECD countries represent 40% of the total value (in billion ECU) in 2000, but only 23% of the physical amount of commodities, this relation is just reversed for the trade with severely indebted countries which contribute only 7% to the total import value of the EU in 2000, but 16% in physical terms. This is reflected by the average price of imported commodities which is 2.7 ECU per kg for high income OECD countries, but only 0.3 ECU per kg for severely indebted countries, far below the average price of 0.7 ECU per kg for all commodities imports. Furthermore, the value of all imports of the EC/EU from SIC countries increased only by about 300% from 1976 to 2000, far below the average of 550% for total trade.

To sum up, from 1976 to 2000 physical imports of the EC/EU had been associated with increasing total material resource requirements abroad. This concerns especially severely indebted countries which obviously increase pressure on natural resources on their territory in order to achieve income from exports. However, their earnings from this sale of resources - as concerns the trade with the EU – are far below those of high income countries and even much lower than the average of all imports. In other words, the EC/EU imported from 1976 to 2000 increasingly cheap but resource intensive commodities especially from severely indebted countries.

The export structure of the EU-15 in 2000 is less complex than the structure of imports (Table 40). Exports of physical commodities, as well as the TMR of exports and the values of exports are directed primarily to high income OECD countries and to middle income countries, together exports to these countries account for 77% for absolute exports, 76% of the TMR of exports and 82% of the value of exports. Poor and highly indebted countries receive only minor amounts of exports from the EU. This imbalance had even significantly increased from 1976 to 2000. High income OECD countries also received commodities of significantly higher average value than poor and indebted countries. Also this tendency had increased from 1976 to 2000. It is further underlined by the ratio of import to export prices which was higher for OECD countries (0.5) than for SIC countries (0.2) in 2000 (average ratio for all commodities was 0.3).
The net effect of bilateral foreign trade of the EU is indicated by the physical and monetary trade balances (Table 40). In absolute physical terms the EU-15 in 2000 required 1 billion tonnes more commodities from other countries than it provided to the rest of the world. This imbalance even increased from 1976 to 2000 by 32%. Furthermore, it concerns all income classes and indebted countries with the only exception for high income non-OECD countries to which the EU provided more commodities in tonnes than it received. In principle the same situation as for the absolute physical PTB is observed for the PTB of the TMR, although the latter had increased significantly more than the former (by 114% from 1976 to 2000 as compared with 32% increase for the absolute PTB). The monetary trade balance of the EU-15 in 2000 is slightly positive at 89 billion tonnes. However, the values of imports and exports are at a similar absolute level which lies well above the value of the MTB. Furthermore from 1976 to 2000 the MTB of the EC/EU was varying between positive and negative values. So, changes occurred rather in cycles than as a continuous trend from 1976 to 2000. Export surplus was observed from 1993 to 1998 and import surplus from 1976 to 1992 (except 1986) as well as in 1999 and 2000. So, the monetary trade balance of the EC/EU was rather balanced whereas the physical trade balances continuously and increasingly showed significant net requirements of resources from the rest of the world.
Table 40: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for countries income classes and for severely indebted countries and highly indebted poor countries.

<table>
<thead>
<tr>
<th>Imports absolute</th>
<th>Imports TMR</th>
<th>Imports value</th>
<th>Exports absolute</th>
<th>Exports TMR</th>
<th>Exports value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>1.431</td>
<td>51%</td>
<td>8.566</td>
<td>96%</td>
<td>1.027</td>
</tr>
<tr>
<td>Low income countries</td>
<td>102</td>
<td>31%</td>
<td>903</td>
<td>24%</td>
<td>60</td>
</tr>
<tr>
<td>Lower middle income countries</td>
<td>405</td>
<td>44%</td>
<td>2.065</td>
<td>122%</td>
<td>205</td>
</tr>
<tr>
<td>Upper middle income countries</td>
<td>445</td>
<td>57%</td>
<td>3.092</td>
<td>196%</td>
<td>224</td>
</tr>
<tr>
<td>High income: nonOECD countries</td>
<td>31</td>
<td>-65%</td>
<td>197</td>
<td>-30%</td>
<td>82</td>
</tr>
<tr>
<td>High income: OECD countries</td>
<td>326</td>
<td>49%</td>
<td>2.052</td>
<td>48%</td>
<td>412</td>
</tr>
<tr>
<td>Unspecified Extra trade</td>
<td>123</td>
<td>#DIV/0!</td>
<td>257</td>
<td>#DIV/0!</td>
<td>45</td>
</tr>
<tr>
<td>Income classes: missing trade</td>
<td>0</td>
<td>-100%</td>
<td>0</td>
<td>-100%</td>
<td>0</td>
</tr>
<tr>
<td>Severely indebted countries</td>
<td>222</td>
<td>35%</td>
<td>2.079</td>
<td>149%</td>
<td>68</td>
</tr>
<tr>
<td>Heavily indebted poor countries (HIPC)</td>
<td>38</td>
<td>0%</td>
<td>521</td>
<td>22%</td>
<td>19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PTB absolute</th>
<th>PTB TMR</th>
<th>MTB</th>
<th>Imports price</th>
<th>Exports price</th>
<th>Import-/Export- price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>1.006</td>
<td>32%</td>
<td>6.259</td>
<td>114%</td>
<td>89</td>
</tr>
<tr>
<td>Low income countries</td>
<td>71</td>
<td>13%</td>
<td>679</td>
<td>7%</td>
<td>14</td>
</tr>
<tr>
<td>Lower middle income countries</td>
<td>332</td>
<td>36%</td>
<td>1.595</td>
<td>137%</td>
<td>77</td>
</tr>
<tr>
<td>Upper middle income countries</td>
<td>348</td>
<td>31%</td>
<td>2.585</td>
<td>183%</td>
<td>2</td>
</tr>
<tr>
<td>High income: nonOECD countries</td>
<td>-6</td>
<td>-107%</td>
<td>-35</td>
<td>-117%</td>
<td>-21</td>
</tr>
<tr>
<td>High income: OECD countries</td>
<td>168</td>
<td>31%</td>
<td>1.258</td>
<td>125%</td>
<td>3</td>
</tr>
<tr>
<td>Unspecified Extra trade</td>
<td>93</td>
<td>#DIV/0!</td>
<td>177</td>
<td>#DIV/0!</td>
<td>18</td>
</tr>
<tr>
<td>Income classes: missing trade</td>
<td>0</td>
<td>-100%</td>
<td>0</td>
<td>-100%</td>
<td>0</td>
</tr>
<tr>
<td>Severely indebted countries</td>
<td>192</td>
<td>30%</td>
<td>1.934</td>
<td>164%</td>
<td>17</td>
</tr>
<tr>
<td>Heavily indebted poor countries (HIPC)</td>
<td>24</td>
<td>-20%</td>
<td>453</td>
<td>22%</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: #DIV/0! = value in 1976 is zero.
Foreign trade with developing and newly industrializing countries

The foreign trade of the EC/EU was analyzed with respect to physical and monetary exchange of commodities with developing countries outside Europe and with newly industrializing countries in Europe and outside Europe (for detailed countries listing see Table A5 in the annex).

Developing countries outside Europe (DC) played an important role for physical imports of the EU-15 in 2000 (Table 41). 41% of all commodities imported by the EU came from developing countries, and even 51% of the TMR of imports, indicating the overproportional contribution of DC to resource intensive commodities. Furthermore, the resource intensity of imports of the EC/EU from DC had increased significantly from 1976 to 2000. The TMR of imports from DC had increased by 67% from 1976 to 2000 whereas absolute imports had remained almost constant (-2%). Contrary to physical imports, the share of the DC for monetary imports by the EU was only 36% in 2000 which shows that their provision of resource intensive commodities was associated with values below the average of commodities imported by the EU. This is also reflected by the average import price of commodities from DC which was 0.6 in 2000 as compared with 0.7 for total trade. However, this average price for commodities from DC had increased more from 1976 to 2000 than the average price for total trade, indicating a relatively positive development for exported resources’ values from the DC to the EU. On the other hand, absolute values of imports of the EC/EU from 1976 to 2000 had increased less (by 421%) than total trade (by 551%), indicating relative loss of trade share of DC with the EU market.

Also exports of the EU-15 in 2000 went to a significant part to developing countries outside Europe. Contrary to imports, the relative shares of absolute commodities exports (31%), TMR of exports (39%), and values of exports (30%) were not as much different from each other. Compared with total trade, the EC/EU had exported from 1976 to 2000 relatively more physical commodities (149% more exports to DC versus 128% for total trade), associated also with more total material requirements (135% for DC versus 59% for total trade), but less value in ECU (431% for DC versus 564% for total trade). So, in physical terms DC played an increasing role for exports of the EC/EU, but in monetary terms DC lost relative trade shares with the EU market, for exports as well as for imports. The average price of exports of the EU-15 to DC was 2.1 ECU per kg, almost the same as for total trade (2.2 ECU per kg). From 1976 to 2000 the EC/EU had exported increasingly higher priced commodities to DC, however, to a lesser degree than for all commodities on the average (the average price of
exports to DC increased by 114% as compared with 191% for total trade). The ratio of imports to exports prices for trade of the EU-15 in 2000 with DC was 0.3, the same as for total trade. This ratio had increased from 1976 to 2000 by 149% as compared with 48% for total trade, indicating a slightly positive development for DC by increasing the average value of their exported commodities to the EC/EU relatively over the value of their imports from the EC/EU. Also, the monetary trade balance of DC with the EU-15 in 2000 is positive, i.e. the DC acquired net value by trade with the EU. For this, the DC provided more physical commodities associated with total material requirements to the EU than they received from the EU, the absolute physical trade balance for DC was 457 million tonnes in 2000 (45% of total trade), the TMR of PTB was even 3439 million tonnes in 2000 (55% of total trade).

To sum up, foreign trade of the EC/EU with developing countries outside Europe has a relatively high importance, for imports as well as for exports, for physical exchange as well as for monetary exchange. However, in monetary terms the DC lost shares for trade with the EU-market during 1976 to 2000. Contrary, DC are rather constantly a major source for foreign physical resource requirements of the EC/EU, especially as regards the total material requirement whose development shows that the EC/EU had required increasingly resource intensive commodities from DC during the period 1976 to 2000. A positive signal for development of the foreign trade of DC with the EC/EU is the increasing export of commodities of higher value, which is above the average of total trade, associated with an improvement of the relation of commodity prices of the DC to prices of commodities received from the EC/EU.

Least developed countries (LDC) play only a minor role for the foreign trade of the EC/EU (Table 41). This concerns all parameters, physical as well as monetary ones, those for imports as well as those for exports. LDC have in common with DC that their exports to the EC/EU had become increasingly resource intensive during 1976 to 2000. But, compared with DC, LDC had lost even more relative trade shares in monetary terms with the EC/EU during 1976 to 2000. Furthermore, in contrast to DC, the development of the average price of commodities imported by the EC/EU from LDC increased only below the average for total trade. Still, the monetary trade balance (MTB) of LDC with the EU-15 was positive in 2000 (plus 1 billion ECU), a positive development for LDC after constantly negative MTB values from 1976 to 1998.

Newly industrializing countries (NIC) outside Europe contributed significantly to the foreign trade of the EU-15 in 2000 (Table 41). NIC outside Europe in 2000 held 20% of absolute imports, 32% of the TMR of imports, 19% of the value of imports, 12% of absolute exports,
16% of the TMR of exports, and 17% of the value of exports of the EU. Thus, a similar picture as for DC can be observed for NIC outside Europe, especially as regards the relative high resource intensity of commodities exported to the EU. However, contrary to DC, the TMR of imports by the EC/EU from NIC outside Europe had increased less (by 126%) than absolute imports of commodities (by 141%), indicating a development towards less resource intensive commodity trade. Furthermore, the value of imports of the EC/EU from NIC outside Europe had increased from 1976 to 2000 by 813%, well above the import values of all commodities (by 551%) and commodities from DC (by 421%). The average import price for commodities from NIC outside Europe was 0.7 ECU per kg in 2000 in the EU-15, the same as for total trade. On the other hand, the EU exported commodities at a much higher average price of 3.2 ECU per kg to NIC outside Europe than for its total trade (2.2 ECU per kg). This may be due to high value commodities contributing to further development of NIC outside Europe by acquisition of investment goods which could be analysed in further studies. Still, the monetary trade balance was in favour of NIC outside Europe in 2000 (plus 34 billion ECU, by 1440% more than in 1976). All parameters for foreign trade between the EC/EU and NIC outside Europe had increased significantly during 1976 to 2000, and mostly more than parameters for total trade. This indicates that industrial development in the NIC outside Europe was associated with a significant increase of their general involvement into the market of the EC/EU which was much more expressed than for developing countries outside Europe in general.

For comparison, the role of newly industrializing countries (NIC) in Europe was analyzed with respect to their external trade with the EC/EU (Table 41). NIC in Europe were aggregated in two different ways: excluding (formerly) centrally planned economies (CPE) and including CPE. So, time series including CPE describe the development with reference to the territorial status of NIC in Europe of today, whereas time series excluding CPE show for comparison the “real” development of NIC in Europe. Naturally, values in 2000 are the same for NIC excluding CPE and NIC including CPE, and only the changes from 1976 to 2000 reflect the different composition of NIC in Europe depending on whether CPE were included in 1976 or not. The analysis will in the following concentrate on NIC including CPE in order to indicate developments brought about by transition of the formerly CPE to the new market economies of Central and Eastern Europe.

Like DC and NIC outside Europe, the NIC in Europe incl. CPE contributed significantly to the foreign trade of the EU-15 in 2000 (Table 41). NIC in Europe incl. CPE in 2000 held 22% of absolute imports, 16% of the TMR of imports, 16% of the value of imports, 20% of
absolute exports, 19% of the TMR of exports, and 19% of the value of exports of the EU. So, in contrast to DC and NIC outside Europe, the share of the TMR of imports of the EU from NIC in Europe incl. CPE in 2000 was significantly lower (16%) than the share of absolute imports (22%), indicating less material resource intensive commodities imports of the EU from NIC in Europe incl. CPE than from DC and NIC outside Europe. However, as for DC outside Europe and in contrast to NIC outside Europe, the TMR of imports from NIC in Europe incl. CPE had increased more (by 309%) from 1976 to 2000 than the absolute physical imports (by 226%) of the EC/EU, indicating also increasing specific resource intensity of exports by NIC in Europe incl. CPE to the EC/EU.

From 1976 to 2000 the EC/EU had increased its imports from NIC in Europe incl. CPE in monetary terms by 1009%, almost twice the average of total trade (551%). Also export values of the EC/EU to the NIC in Europe incl. CPE had increased above average (by 753% versus 564% for total trade) during this period. Also imports and exports in physical terms had increased above average from 1976 to 2000. This indicates an especially fast growing importance of NIC in Europe incl. CPE, among which are many countries that will join the EU from 2004 onwards, as external trade partners of the EU, a development that took place at significantly higher rates than observed for DC and NIC outside Europe. On the other hand, the EU in 2000 bought on the average significantly cheaper commodities from NIC in Europe incl. CPE (0.5 ECU per kg) than from DC (0.6 ECU per kg) and NIC (0.7 ECU per kg) outside Europe, and cheaper even than the average price for total trade (0.7 ECU per kg). In addition, the average import price for commodities from NIC in Europe incl. CPE had increased less from 1976 to 2000 than import prices for DC and NIC outside Europe and for total trade. This indicates that NIC in Europe incl. CPE constitute relatively low price sources for commodities imports by the EC/EU. This is also reflected by the monetary trade balance (MTB) of NIC in Europe incl. CPE with the EU which was negative (minus 12 billion ECU) in 2000 and mostly also during the entire period 1976 to 2000. So, in contrast to DC and NIC outside Europe, the NIC in Europe incl. CPE mostly had to deal with a monetary trade deficit for their market exchange with the EC/EU. In how far this may be due to high value commodities imports from the EU contributing to further development of NIC in Europe incl. CPE by acquisition of investment goods could be analysed in further studies.
Table 41: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for developing countries outside Europe, least developed countries, and newly industrializing countries (NIC) in Europe (incl. and excl. CPE) and outside Europe.

<table>
<thead>
<tr>
<th>Imports absolute</th>
<th>Imports TMR</th>
<th>Imports value</th>
<th>Exports absolute</th>
<th>Exports TMR</th>
<th>Exports value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>1.431</td>
<td>51%</td>
<td>8.566</td>
<td>96%</td>
<td>1.027</td>
</tr>
<tr>
<td>Developing countries outside Europe</td>
<td>588</td>
<td>-2%</td>
<td>4.335</td>
<td>67%</td>
<td>365</td>
</tr>
<tr>
<td>Least developed countries</td>
<td>29</td>
<td>-12%</td>
<td>383</td>
<td>4%</td>
<td>12</td>
</tr>
<tr>
<td>NIC Europe excl. CPE</td>
<td>320</td>
<td>426%</td>
<td>1.410</td>
<td>3900%</td>
<td>166</td>
</tr>
<tr>
<td>NIC Europe incl. CPE</td>
<td>320</td>
<td>426%</td>
<td>1.410</td>
<td>3900%</td>
<td>166</td>
</tr>
<tr>
<td>NIC outside Europe</td>
<td>280</td>
<td>141%</td>
<td>2.772</td>
<td>126%</td>
<td>198</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PTB absolute</th>
<th>PTB TMR</th>
<th>MTB</th>
<th>Imports price</th>
<th>Exports price</th>
<th>Import-/Export- price</th>
<th>Ratio</th>
<th>% Change vs. 1976</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>1.006</td>
<td>32%</td>
<td>6.259</td>
<td>114%</td>
<td>89</td>
<td>445%</td>
<td>0.7</td>
</tr>
<tr>
<td>Developing countries outside Europe</td>
<td>457</td>
<td>-17%</td>
<td>3.439</td>
<td>56%</td>
<td>87</td>
<td>392%</td>
<td>0.6</td>
</tr>
<tr>
<td>Least developed countries</td>
<td>20</td>
<td>-28%</td>
<td>334</td>
<td>2%</td>
<td>1</td>
<td>-581%</td>
<td>0.4</td>
</tr>
<tr>
<td>NIC Europe excl. CPE</td>
<td>234</td>
<td>-3083%</td>
<td>969</td>
<td>-4168%</td>
<td>-12</td>
<td>284%</td>
<td>0.5</td>
</tr>
<tr>
<td>NIC Europe incl. CPE</td>
<td>234</td>
<td>220%</td>
<td>969</td>
<td>488%</td>
<td>-12</td>
<td>106%</td>
<td>0.5</td>
</tr>
<tr>
<td>NIC outside Europe</td>
<td>228</td>
<td>130%</td>
<td>2.404</td>
<td>118%</td>
<td>34</td>
<td>1440%</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Note: NIC = Newly Industrializing Countries; CPE = (former) Centrally Planned Economies.
The results of this study described above indicate towards changing roles for developing and newly industrializing countries with regards to the provision of material resources to the EC/EU. This was further analyzed with respect to the composition of material resources. The result is illustrates in Figure 8 for the major components of the total material resource requirements: imports of raw materials, of semi-manufactured and finished products (together forming the DMI of imports), as well for the respective indirect or hidden flows.

While DMI of imports from developing countries remained relatively constant from 1976 to 2000, DMI increased significantly for imports from NIC in Europe and for NIC outside Europe, both reaching in 2000 about half of the DMI level for developing countries. These increases were mainly due to imports of raw materials. Imports of semi-manufactured and finished products increased slightly from all three regions, but remained on a significantly lower level than imports of raw materials. Thus, developing countries rather stagnate as far as their direct resource input to the EC/EU is concerned, whereas newly industrializing countries increasingly take over the role of providers of raw materials. For all three regions a clear overall change to exports of higher manufacturing levels cannot be observed.

The indirect or hidden flows of raw materials imported from developing countries by the EC/EU increased overproportional as compared with the imports of raw materials in absolute terms, leading to a significant overall increase of the total material requirement for imports of the EC/EU from developing countries. Contrary, indirect or hidden flows of imported semi-manufactured and finished products rather show a fluctuating trend. The same picture shows for imports of the EC/EU from NIC outside Europe.

Another result is obtained for imports of the EC/EU from NIC in Europe: here, the total material resource intensity of raw material imports increased less. But the indirect or hidden flows of semi-manufactured and finished products increased overproportional and dominated the total material requirement for exports to the EC/EU during the 1990s. Exported commodities of this kind are therefore increasingly based on resource intensive production respectively material intensive precursor goods in the NIC in Europe. This may indicate that the EU has increasingly shifted material resource intensive production to the NIC in Central and Eastern Europe. This hypothesis should be further investigated by a comparative analysis of the domestic production of resource intensive goods within the EU. This, however, is currently not feasible because of missing or incomplete data.
Figure 8: Development of imports by the EC/EU 1976-2000 from developing countries and from newly industrializing countries.

Notes: NIC = Newly Industrializing Countries; Total import DMI = raw materials plus semi-manufactured and finished products.

Sources: Eurostat Comext 2001 and own calculations.
In addition to the general analysis it was investigated in this study which commodity imports of the EC/EU from developing countries outside Europe and from newly industrializing countries in Europe increased over average of the absolute physical amounts.

In total, imports from developing countries outside Europe (DC) remained rather constantly high from 1976 to 2000 (whereas the share of imports from DC decreased significantly from ca. 60% in 1976 to ca. 40% in 2000). Contrary, imports of the following commodity groups (Nimexe and CN 2-digit level) from DC to EC/EU increased relatively much: stone articles, furniture, plastics, and railway (Figure 9). Together, these four commodity groups represent a share of only 1% at most of the total import of the EC/EU from DC, however, with increasing tendency (factor 100 versus 1976). On the other hand, especially imports of furs, wool, cereal milling products, and vegetable fibres from DC, i.e. manufactures of primary and basic industries, had decreased significantly. Especially the increase of products like railway, plastics and furniture indicates that also in developing countries outside Europe a change towards export goods of higher value has taken place. Further studies could investigate which products and which countries are concerned, how far this trend is established, and which ecological and social implications are associated with it.

Figure 9: Development of increasing imports of commodity groups from developing countries outside Europe by the EC/EU: 1976-2000.

In total, imports from newly industrializing countries (NIC) in Europe by the EC/EU increased from 1976 to 2000 by 226% (Figure 10). In how far this was associated with a shift of production for domestic demand in the EU could only be investigated by a comparative time series for domestic production and imports, but this is currently not feasible for
production. Imports increasing in absolute amounts indicate at least relative shifts associated with increasing environmental pressure by imports. Rapidly growing imports by the EC/EU from NIC in Europe are observed for the commodity groups: soaps etc., railway, essential oils, and aircraft. Together, these four commodity groups account only for about 0.2% of the total import of the EC/EU from NIC in Europe in 2000, but with increasing tendency (factor 20 from 1976 to 2000). Of decreasing importance were especially imports of cork, silk, natural resins and –lacs, animal- and vegetable fats and oils, and ores – in principle a similar picture as for imports from developing countries outside Europe.

*Figure 10 Development of increasing imports of commodity groups from newly industrializing countries in Europe by the EC/EU: 1976-2000.*


**Foreign trade by geographical regions**

Physical imports of the EU-15 came in 2000 mainly from the rest of Western Europe (13%), the transition economies of the Commonwealth of Independent States (CIS: 12%), Latin America (12%), The Middle East (12%), and from North Africa (9%), together accounting for 59% of all physical commodity imports (Table 42). Geographically unspecified trade (secret data, stores etc.) also had a significant share of 9% and ranked sixth among physical absolute imports by the EU-15 in 2000 (for detailed countries listing see Table A6 in the annex).

Physical imports from the rest of Europe dominated the EU-15’s foreign supply of commodities (34%), followed by America (19%), Africa (17%), Asia (17%), unspecified trade (9%), and Oceania (4%). The highest increase of physical absolute imports from 1976 to 2000 was however recorded for Southern Africa (plus 375%), followed by East Asia (plus...
282%), reflecting these regions strong development towards integration into the global market. On the other hand, the strongest decrease of physical imports by the EC/EU was observed for The Middle East (minus 55%), mainly due to strongly reduced imports of crude oil. Also physical imports from Western Africa and Eastern Africa had decreased from 1976 to 2000 which means that these two rather poor regions are being increasingly excluded from trade with the EU as far as physical imports are concerned.

The total material requirement for imported commodities by the EU-15 in 2000 shows a slightly different picture (Table 42). TMR of imports was highest for commodities from Latin America (22%), East Asia (11%), North America (10%), CIS (9%), and the rest of Western Europe (8%), these top five together accounting for 61% of the TMR of imports of the EU-15 in 2000. The high rankings of Latin America and East Asia are mainly due to imports of highly resource intensive metals and minerals, like non-ferrous ores and concentrates. The TMR of imports from Latin America was also the one who increased most from 1976 to 2000, by 263%, indicating that a great part of the observed overall increase of foreign resource requirements of the EU, mainly in forms of metals and minerals, was located in countries of Middle and South America. This will be further investigated in a following part of this study. Although the TMR of total trade for imports of the EC/EU almost doubled from 1976 to 2000, two regions had succeeded to reduce TMR although their absolute physical exports to the EC/EU increased, these regions are Central Africa and West Asia. The reasons for these success stories could be analyzed in further studies. Contrary, exports of commodities from Western Africa to the EC/EU had been reduced from 1976 to 2000, but their total material requirement had increased during the same period, indicating a negative development towards potential overuse of natural resources for exports which could also be further investigated in future studies.

Imports of the EU-15 in 2000 in monetary terms came mainly from East Asia (27%), North America (21%), the rest of Western Europe (13%), Central and Eastern Europe (8%), and Latin America (5%), together accounting for 75% of all imports in ECU, indicating the economic importance of traditional industrial trade partners and newly industrializing economies especially in East Asia and Europe. In addition, monetary imports by the EC/EU from East Asia had increased most from 1976 to 2000, by 1778%, which is in line with the reported strong development of exports of this region to the global market (WTO Trade Statistics). Contrary, especially monetary imports from sub-saharan Africa, The Middle East and Oceania increased less than total trade from 1976 to 2000, underlining that especially poor regions in Africa have been increasingly excluded from trade with the EU.
The geographical distribution for exports of the EU-15 in 2000 is less complex than for imports (Table 42). Exports in absolute physical terms, as well as the TMR of exports and the value of exports are directed primarily to North America. In addition, for all these three major export parameters the top five regions are identical, i.e. North America, the rest of Western Europe, Central and Eastern Europe, The Middle East and East Asia. Together, these five regions received 70% of the absolute physical exports of the EU-15 in 2000, 71% of the TMR of exports and 76% of the value of exports. The EU’s main export partners are traditional industrial economies and newly industrializing economies in America, Europe and Asia. These links had been manifested over a period of 25 years. From 1976 to 2000 monetary as well as physical exports of the EC/EU increased most for East Asia and North America, and only the increase of the TMR of exports to West Asia was higher than to East Asia and North America. The structure of exports of the EU, thus, shows a rather conservative pattern as compared with imports. Regions of sub-saharan Africa play only a minor role for exports of the EU.

Most expensive commodities were imported by the EU-15 in 2000 from East and West Asia, North America, Eastern Africa and Central and Eastern Europe (Table 42). Contrary, imports from Oceania, Western Africa, CIS, Latin America, The Middle East, North Africa, The Baltic States, and Southern Africa were purchased at less than half of the average price for all commodities of 0.7 ECU per kg. Obviously, these regions, being mostly not the primary trade partners of the EU, rather serve for delivering low price material resources to the EU for further manufacturing or consumption, whereas exports of the EU primarily go to regions of higher average income. On the other hands, Oceania, Southern Africa and Latin America range among the top five regions that received on the average most expensive commodities by exports from the EU-15 in 2000 (the other two regions being East Asia and North America). In addition, these three regions, Oceania, Southern Africa and Latin America, recorded a negative development of the ratio of imports to export prices for trade with the EC/EU from 1976 to 2000 (along with Central Africa and the rest of Western Europe). For Oceania and Latin America the monetary trade balance with the EU-15 in 2000 is negative (for Southern Africa it is positive with 5 billion ECU), whereas the physical trade balances (absolute and for TMR) for all three regions are positive. To sum up, these parameters point towards a development of trade of Oceania, Southern Africa and Latin America with the EU that is characterized by an increasing net provision of natural resources at increasingly unfavourable economic conditions. This could be further analyzed in a future study.
The physical trade balances (absolute and for TMR) of the EU-15 in 2000 are positive for all regions except for absolute PTB with Eastern Africa which is almost balanced. Thus, the EU acquired more resources from almost every major region of the world than it provided to there. This unequal physical exchange had especially increased in absolute terms from 1976 to 2000 for the trade with the rest of Western Europe and Southern Africa, for total material requirement it had increased most during this period for the trade with Latin America and Oceania. On the other hand, less unequal exchange for commodities and TMR was recorded for trade of the EC/EU with North America, Eastern Africa and The Middle East.

The positive monetary trade balance of the EU-15 in 2000 was primarily due to a surplus of import value over export value for the trade with East Asia, whereas trade with regions in America and Europe resulted in surplus of exports value of the EU over imports value.
Table 42: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for geographical regions.

<table>
<thead>
<tr>
<th></th>
<th>Imports absolute</th>
<th>Imports TMR</th>
<th>Imports value</th>
<th>Exports absolute</th>
<th>Exports TMR</th>
<th>Exports value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>1.431</td>
<td>51%</td>
<td>8.566</td>
<td>96%</td>
<td>1.027</td>
<td>551%</td>
</tr>
<tr>
<td>North America</td>
<td>101</td>
<td>6%</td>
<td>864</td>
<td>34%</td>
<td>214</td>
<td>626%</td>
</tr>
<tr>
<td>Latin America</td>
<td>173</td>
<td>155%</td>
<td>1.911</td>
<td>263%</td>
<td>52</td>
<td>459%</td>
</tr>
<tr>
<td>Western Europe excl. EUR</td>
<td>190</td>
<td>112%</td>
<td>699</td>
<td>47%</td>
<td>132</td>
<td>305%</td>
</tr>
<tr>
<td>Central and Eastern Europe</td>
<td>96</td>
<td>7%</td>
<td>476</td>
<td>55%</td>
<td>84</td>
<td>670%</td>
</tr>
<tr>
<td>Baltic States</td>
<td>22</td>
<td>#DIV/0!</td>
<td>57</td>
<td>#DIV/0!</td>
<td>7</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>Commonwealth of Independent States (transition economies)</td>
<td>177</td>
<td>#DIV/0!</td>
<td>760</td>
<td>#DIV/0!</td>
<td>47</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>North Africa</td>
<td>131</td>
<td>49%</td>
<td>362</td>
<td>96%</td>
<td>40</td>
<td>401%</td>
</tr>
<tr>
<td>Western Africa</td>
<td>49</td>
<td>-25%</td>
<td>472</td>
<td>92%</td>
<td>12</td>
<td>103%</td>
</tr>
<tr>
<td>Central Africa</td>
<td>12</td>
<td>89%</td>
<td>59</td>
<td>-55%</td>
<td>5</td>
<td>181%</td>
</tr>
<tr>
<td>Eastern Africa</td>
<td>2</td>
<td>-16%</td>
<td>36</td>
<td>-39%</td>
<td>4</td>
<td>198%</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>55</td>
<td>375%</td>
<td>446</td>
<td>95%</td>
<td>18</td>
<td>381%</td>
</tr>
<tr>
<td>The Middle East</td>
<td>170</td>
<td>-55%</td>
<td>478</td>
<td>-28%</td>
<td>52</td>
<td>59%</td>
</tr>
<tr>
<td>West Asia</td>
<td>9</td>
<td>135%</td>
<td>127</td>
<td>-14%</td>
<td>20</td>
<td>915%</td>
</tr>
<tr>
<td>East Asia</td>
<td>65</td>
<td>282%</td>
<td>978</td>
<td>96%</td>
<td>282</td>
<td>1778%</td>
</tr>
<tr>
<td>Oceania</td>
<td>57</td>
<td>68%</td>
<td>583</td>
<td>129%</td>
<td>12</td>
<td>156%</td>
</tr>
<tr>
<td>Unspecified Extra</td>
<td>123</td>
<td>#DIV/0!</td>
<td>257</td>
<td>#DIV/0!</td>
<td>45</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>Geographical: missing</td>
<td>0</td>
<td>-100%</td>
<td>0</td>
<td>-100%</td>
<td>0</td>
<td>-98%</td>
</tr>
</tbody>
</table>
Table 35 - continued: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for geographical regions.

<table>
<thead>
<tr>
<th>Geographical regions</th>
<th>PTB absolute</th>
<th>PTB TMR</th>
<th>MTB</th>
<th>Imports price</th>
<th>Exports price</th>
<th>Import-/Export-price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>1.006</td>
<td>32%</td>
<td>6.259</td>
<td>114%</td>
<td>89</td>
<td>445%</td>
</tr>
<tr>
<td>North America</td>
<td>9</td>
<td>-88%</td>
<td>400</td>
<td>-17%</td>
<td>-37</td>
<td>-442%</td>
</tr>
<tr>
<td>Latin America</td>
<td>152</td>
<td>157%</td>
<td>1.804</td>
<td>281%</td>
<td>-7</td>
<td>-1888%</td>
</tr>
<tr>
<td>Western Europe excl. EUR</td>
<td>102</td>
<td>498%</td>
<td>281</td>
<td>-280%</td>
<td>-17</td>
<td>14%</td>
</tr>
<tr>
<td>Central and Eastern Europe</td>
<td>52</td>
<td>-30%</td>
<td>264</td>
<td>45%</td>
<td>-14</td>
<td>793%</td>
</tr>
<tr>
<td>Baltic States</td>
<td>18</td>
<td>#DIV/0!</td>
<td>39</td>
<td>#DIV/0!</td>
<td>-0</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>Commonwealth of Independent States (transition economies)</td>
<td>165</td>
<td>#DIV/0!</td>
<td>681</td>
<td>#DIV/0!</td>
<td>20</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>North Africa</td>
<td>102</td>
<td>33%</td>
<td>205</td>
<td>86%</td>
<td>9</td>
<td>-2106%</td>
</tr>
<tr>
<td>Western Africa</td>
<td>37</td>
<td>-36%</td>
<td>420</td>
<td>121%</td>
<td>-1</td>
<td>219%</td>
</tr>
<tr>
<td>Central Africa</td>
<td>10</td>
<td>136%</td>
<td>48</td>
<td>-59%</td>
<td>2</td>
<td>550%</td>
</tr>
<tr>
<td>Eastern Africa</td>
<td>-0</td>
<td>-108%</td>
<td>24</td>
<td>-51%</td>
<td>-0</td>
<td>-36%</td>
</tr>
<tr>
<td>Southern Africa</td>
<td>51</td>
<td>451%</td>
<td>423</td>
<td>98%</td>
<td>5</td>
<td>2174%</td>
</tr>
<tr>
<td>The Middle East</td>
<td>135</td>
<td>-63%</td>
<td>276</td>
<td>-50%</td>
<td>-9</td>
<td>-153%</td>
</tr>
<tr>
<td>West Asia</td>
<td>1</td>
<td>21%</td>
<td>18</td>
<td>-85%</td>
<td>3</td>
<td>2958%</td>
</tr>
<tr>
<td>East Asia</td>
<td>26</td>
<td>158%</td>
<td>634</td>
<td>55%</td>
<td>124</td>
<td>2130%</td>
</tr>
<tr>
<td>Oceania</td>
<td>53</td>
<td>69%</td>
<td>564</td>
<td>144%</td>
<td>-7</td>
<td>-627%</td>
</tr>
<tr>
<td>Unspecified Extra</td>
<td>93</td>
<td>#DIV/0!</td>
<td>177</td>
<td>#DIV/0!</td>
<td>18</td>
<td>#DIV/0!</td>
</tr>
<tr>
<td>Geographical: missing</td>
<td>-0</td>
<td>-100%</td>
<td>-0</td>
<td>-100%</td>
<td>-0</td>
<td>-96%</td>
</tr>
</tbody>
</table>

Note: #DIV/0! = value in 1976 is zero.
Foreign trade by economic regions


Foreign trade of the EU-15 in 2000 is dominated among economic regions by trade with the OECD and APEC (Table 43). For imports as well as for exports, for physical commodities and their TMR as well as for monetary values, trade of the EU with the OECD and APEC always ranked among the top five of economic regions. This is even so for the two sub-components of the OECD, OECD excluding European countries and OECD Europe. Besides this, especially the NAFTA exported significant value (21% of total trade) to the EU-15 in 2000, and high shares of physical exports (22%), TMR of exports (21%), and exports value (28%) of the EU were going to the NAFTA. From the MERCOSUR, the EU imported about 14% of the TMR of imports in 2000 (rank 4). Physical imports in absolute terms were coming by 22% in 2000 from OPEC countries (rank 3). Candidate countries ranked in the midfield of economic regions’ trade with the EU-15 in 2000, their relative importance for exports of the EU was slightly higher than for imports. Trade with candidate countries mostly had a higher relevance than trade with EFTA countries. Foreign trade with ACP countries was below 10% of total imports or exports of the EU-15 in 2000 except for the TMR of imports which was 12% (rank 6). The MEDITERRANEAN BASSIN was a trade partner of minor importance for the EU-15 in 2000, even more so the ASEAN region.

From 1976 to 2000 almost all parameters of foreign trade of the EC/EU, for imports as well as for exports, for physical as well as for monetary values, with the economic regions studied had increased. There are only a four exceptions: absolute physical imports from OPEC had decreased by 33% because of reduced oil imports, absolute physical exports to EFTA
countries had decreased slightly by 6%, also the TMR of exports to EFTA countries (minus 48%) had declined as well as the TMR of exports to OECD Europe (minus 8%). On the other hand, foreign trade of the EC/EU with Candidate Countries had increased for all parameters at almost always highest rates from 1976 to 2000, indicating intensive interlinkages with the economies that will sooner or later become Member States of the European Union. Foreign trade of the EC/EU with the most important partner among economic regions, the OECD, increased rather similar to the average increase of total trade for all parameters. Foreign trade with the second most important partner, the APEC, increased for all parameters well above the average increase for total trade, which is in line with the result of the increasing importance of East Asia as trade partner of the EU. Surprisingly, all trade parameters indicate less increase of foreign trade of the EC/EU with ACP countries than the average increase for total trade, ACP countries from 1976 to 2000 obviously lost significant shares of the global trade with the EC/EU. Contrary, the economic regions with low overall contributions to foreign trade of the EC/EU, MEDITERRANEAN BASSIN and ASEAN, had increased imports as well as exports, monetary as well as physical trade, above averages for total trade. The development of trade of the EC/EU with NAFTA countries is characterized by much higher relative increases of exports than of imports.

The EU-15 in 2000 imported on the average rather expensive commodities from ASEAN, NAFTA, and OECD excl. Europe (Table 43), and these prices had also increased most from 1976 to 2000. Least expensive commodities on the average came in 2000 from MERCOSUR, OPEC and ACP, indicating that these regions rather function as providers of low priced raw materials or commodities of a lower manufacturing level. On the other hand, the MERCOSUR imported on the average more high value commodities from the EU-15 in 2000 (3.2 ECU per kg) than almost any other economic region and than the average for total trade (2.2 ECU per kg). This may be due to imports of high value investment goods required for industrial development in the MERCOSUR countries, which could be investigated in further studies. As a consequence of low import value and high export value commodities, the import to export price ratio of the MERCOSUR trade with the EC/EU was the lowest recorded for the economic regions studied (0.1). Furthermore, this ratio had even decreased from 1976 to 2000 by 32%, indicating negative development of the terms of trade for the MERCOSUR with the EC/EU. Contrary, the ratio of import to export prices was highest for the NAFTA and it had increased more than the ratio for total trade from 1976 to 2000, indicating negative development of the terms of trade for the EC/EU especially with the NAFTA.
The physical trade balances of the EU-15 in 2000, for absolute physical trade as well as for TMR, were positive for all economic regions studied, indicating net material supply to the EU in all cases. Especially OPEC countries contributed most to the PTB absolute by large exports of crude oil to the EU. The PTB of TMR was determined most by trade of the EU with APEC countries, followed by OECD and MERCOSUR, indicating high net total resource requirements of the EU for metals, mineral commodities and fossil fuels in these regions. For the MERCOSUR, the PTB of TMR had also increased most from 1976 to 2000, by 358%, another evidence for especially high resource requirements of the EU in Latin America. On the other hand, the PTB of TMR had decreased most from 1976 to 2000 for trade of the EC/EU with OECD countries in Europe (minus 1370%), indicating declining net total resource demands of the EU in economically advanced regions of Europe, associated with a shift of this demand to developing regions like Latin America. This could be further investigated in future studies. The net commodity requirement (PTB absolute) had increased from 1976 to 2000 most for EFTA countries (by 772%) and it had decreased especially for NAFTA countries (minus 77%). The increase from 1976 to 2000 of PTB absolute for the MERCOSUR was less pronounced (plus 150%) than the increase for PTB of TMR (plus 358%), pointing once more to the exceptional role of countries in Latin America as providers of increasingly total material resource intensive commodities for the EU.

The monetary trade balance of the EU-15 in 2000 showed a surplus of import value especially for trade with the APEC, followed by OPEC and ASEAN. The MTB for ASEAN showed an unusual change from 1976 to 2000, it had changed from minus 24 million ECU in 1976 to 26 billion ECU in 2000, i.e. by minus 105841%. The highest surpluses of export values over import values for the trade with the EU-15 in 2000 were observed for NAFTA countries (minus 42 billion ECU) and Candidate Countries (minus 31 billion ECU) which reached a net gain of value from trade with the EU. The development of the MTB of these two regions with the EC/EU from 1976 to 2000 was, however, different. Whereas the Candidate Countries had increased their MTB from minus 3 billion ECU in 1976 to 31 billion ECU in 2000 (by 853%), the NAFTA region had turned a positive MTB in 1976 (plus 10 billion ECU) towards a negative MTB in 2000 (minus 42 billion ECU), thus changing from a net importer of value from the EC to a net exporter of value to the EU.
Table 43: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for economic regions.

<table>
<thead>
<tr>
<th>Imports absolute</th>
<th>Imports TMR</th>
<th>Imports value</th>
<th>Exports absolute</th>
<th>Exports TMR</th>
<th>Exports value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill. T</td>
<td>% Change vs. 1976</td>
<td>Mill. T</td>
<td>% Change vs. 1976</td>
<td>Bill. ECU</td>
<td>% Change vs. 1976</td>
</tr>
<tr>
<td>Total trade</td>
<td>1.431</td>
<td>51%</td>
<td>8.566</td>
<td>96%</td>
<td>1.027</td>
</tr>
<tr>
<td>EFTA</td>
<td>163</td>
<td>144%</td>
<td>577</td>
<td>63%</td>
<td>103</td>
</tr>
<tr>
<td>ACP</td>
<td>124</td>
<td>38%</td>
<td>1.033</td>
<td>52%</td>
<td>43</td>
</tr>
<tr>
<td>MED.BASSIN</td>
<td>113</td>
<td>105%</td>
<td>357</td>
<td>149%</td>
<td>60</td>
</tr>
<tr>
<td>OPEC</td>
<td>321</td>
<td>-33%</td>
<td>1.013</td>
<td>5%</td>
<td>82</td>
</tr>
<tr>
<td>ASEAN</td>
<td>31</td>
<td>193%</td>
<td>286</td>
<td>4%</td>
<td>65</td>
</tr>
<tr>
<td>CC</td>
<td>137</td>
<td>272%</td>
<td>621</td>
<td>258%</td>
<td>117</td>
</tr>
<tr>
<td>NAFTA</td>
<td>112</td>
<td>18%</td>
<td>908</td>
<td>34%</td>
<td>220</td>
</tr>
<tr>
<td>MERCOSUR</td>
<td>98</td>
<td>149%</td>
<td>1.216</td>
<td>344%</td>
<td>23</td>
</tr>
<tr>
<td>APEC</td>
<td>390</td>
<td>171%</td>
<td>3.432</td>
<td>125%</td>
<td>556</td>
</tr>
<tr>
<td>OECD excl. Europe</td>
<td>179</td>
<td>39%</td>
<td>1.578</td>
<td>64%</td>
<td>341</td>
</tr>
<tr>
<td>OECD</td>
<td>443</td>
<td>95%</td>
<td>2.611</td>
<td>78%</td>
<td>533</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>264</td>
<td>170%</td>
<td>1.033</td>
<td>104%</td>
<td>192</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PTB absolute</th>
<th>PTB TMR</th>
<th>MTB</th>
<th>Imports price</th>
<th>Exports price</th>
<th>Import-/Export-price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill. T</td>
<td>% Change vs. 1976</td>
<td>Mill. T</td>
<td>% Change vs. 1976</td>
<td>Bill. ECU</td>
<td>% Change vs. 1976</td>
</tr>
<tr>
<td>Total trade</td>
<td>1.006</td>
<td>32%</td>
<td>6.259</td>
<td>114%</td>
<td>89</td>
</tr>
<tr>
<td>EFTA</td>
<td>112</td>
<td>772%</td>
<td>324</td>
<td>-342%</td>
<td>6</td>
</tr>
<tr>
<td>ACP</td>
<td>102</td>
<td>35%</td>
<td>919</td>
<td>57%</td>
<td>5</td>
</tr>
<tr>
<td>MED.BASSIN</td>
<td>53</td>
<td>34%</td>
<td>65</td>
<td>42%</td>
<td>-25</td>
</tr>
<tr>
<td>OPEC</td>
<td>284</td>
<td>-39%</td>
<td>803</td>
<td>-0%</td>
<td>29</td>
</tr>
<tr>
<td>ASEAN</td>
<td>19</td>
<td>129%</td>
<td>218</td>
<td>-14%</td>
<td>26</td>
</tr>
<tr>
<td>CC</td>
<td>66</td>
<td>163%</td>
<td>273</td>
<td>201%</td>
<td>-31</td>
</tr>
<tr>
<td>NAFTA</td>
<td>18</td>
<td>-77%</td>
<td>429</td>
<td>-16%</td>
<td>-42</td>
</tr>
<tr>
<td>MERCOSUR</td>
<td>91</td>
<td>150%</td>
<td>1.188</td>
<td>358%</td>
<td>0</td>
</tr>
<tr>
<td>APEC</td>
<td>243</td>
<td>109%</td>
<td>2.530</td>
<td>103%</td>
<td>94</td>
</tr>
<tr>
<td>OECD excl. Europe</td>
<td>70</td>
<td>-35%</td>
<td>1.010</td>
<td>37%</td>
<td>1</td>
</tr>
<tr>
<td>OECD</td>
<td>232</td>
<td>63%</td>
<td>1.541</td>
<td>122%</td>
<td>-17</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>163</td>
<td>355%</td>
<td>531</td>
<td>-1370%</td>
<td>-18</td>
</tr>
</tbody>
</table>

Notes: EFTA (European Free Trade Association), ACP (African, Caribbean and Pacific Group of States), OPEC (Organization of the Petroleum Exporting Countries), ASEAN (Association of Southeast Asian Nations), CC (Candidate Countries), NAFTA (North American Free Trade Agreement), MERCOSUR (Mercado Común del Sur), APEC (Asia-Pacific Economic Cooperation), OECD (Organisation for Economic Co-operation and Development).
Foreign trade by major trade partners

The foreign trade of the EC/EU from 1976 to 2000 was further analyzed for major trade partners. These were selected by ranking and selecting the top five Non-EU-15 countries with respect to the major six trade parameters: absolute physical imports, TMR of imports, value of imports, absolute physical exports, TMR of exports, and value of exports. The rankings were further performed for the time series 1976 to 1987 (Nimexe classification) and 1988 to 2000 (CN classification) resulting in a potential of 60 trade partners if no doubles occurred. Actually, 34 trade partners resulted from the ranking procedure, among which were 29 countries and 5 undefined trade categories as shown in Table 44.

Absolute physical imports of the EU-15 in 2000 came mainly from Russia (10%), Norway (10%), secret countries (7%), Brazil (6%), and USA (5%) (Table 44). Among these five Brazil also had the highest TMR of imports by the EU in 2000 (14%), followed by Russia (7%), Australia (7%), China (6%) and USA (6%). So, Australia and China are highlighted because of high total material resource requirements of their exports to the EU in 2000. Monetary imports by the EU-15 in 2000 came mainly from USA (19%), Japan (8%), China (7%), Switzerland (6%), and Norway (4%). Thus, imports from Switzerland and Japan are characterized by high values and low materials, indicating that the foreign trade of advanced service economies can be based on low material resource requirements.

Among the top five countries for absolute physical imports of the EU-15 in 2000, imports from Norway had increased most from 1976 to 2000, by 855%, mainly due to natural gas and crude oil. Imports from Brazil also increased significantly more (149%) than the average of total trade increase (51%), whereas imports of commodities from USA remained almost the same in physical terms (plus 4% from 1976 to 2000). The most obvious increase, however, was observed for physical imports of the EC/EU from China which went up by 2124% from 1876 to 2000, indicating the opening of the Chinese market especially during the 1990s. The TMR of imports of the EC/EU increased from 1976 to 2000 for the main contributors in 2000, i.e. Brazil, Australia, China and USA, but increases extraordinarily high for (plus 1094%), higher than the average for total trade (96%) for Australia (191%) and Brazil (419%), but –as for absolute physical imports- again low for USA (9%). Thus, China had at least not increased its TMR if exports to the EU at the same rate as it had increased its absolute commodity exports, indicating a relative decoupling of the natural resource intensity of Chinese exports.

Furthermore, China had the most remarkable increase of monetary exports to the EC/EU from 1976 to 2000 which was 5776%. Compared with the development of physical imports and
their TMR, this indicates that the resource productivity of Chinese exports to the EU had increased significantly which confirms a rather positive development towards less resource intensive imports of the EU from China. Also the other four top exporters of value to the EU in 2000, Japan, Switzerland, USA and Norway, had increasingly contributed above the average for total trade to monetary imports of the EC/EU.

Main trade partners of the EU-15 in 2000 for exports in absolute physical terms were the U.S. (20%), Switzerland (8%), Poland (4%), Norway (4%), secret countries (4%), and Turkey (3%), all developed or industrializing economies. The U.S. also caused most of the total material resource requirement of exports by the EU (18%), and the second highest TMR of exports was also –like absolute physical exports – allocated to Switzerland (8%). Next in the ranking were China (5% of TMR of exports) and India (4% of TMR of exports) which, thus, received relatively high resource intensive commodities from the EU in 2000. Turkey was on position 5 for TMR of exports of the EU, similar to its position (6) for absolute exports in physical terms in 2000.

Once more, the USA was trade partner number one for monetary exports of the EU-15 in 2000. Almost one quarter (24%) of the total export value in 2000 was derived from commodities sold by the EU to the U.S. market. And, again Switzerland took position two (7%), followed by Japan (5%), Poland (4%) and Turkey (3%).

Thus, main trade partners for exports of the EU-15 in 2000 were mainly the U.S. and Switzerland. For absolute physical exports and its TMR, as well as for monetary exports, USA always held position one and Switzerland had always position two. Also the other main trade partners were mostly developed or industrializing economies in Europe, with the only exception that Japan was a major partner in monetary terms and China and India received relatively high resource intensive exports from the EU. The export structure of the EU appears rather restricted with respect to the great diversity of economies on the global scale, indicating especially high dependency on the USA and Switzerland.

This dependency on the U.S. market is even growing. From 1976 to 2000, the EC/EU had increased its physical commodity export as well as the monetary export to the USA well above the average increase for total trade of these two parameters. Also the TMR of exports to the U.S. had increased above average of total trade, indicating high resource intensity of export commodities. Contrary, the relevance of Switzerland as trade partner of the EU had slightly declined, the three main parameters for exports of the EC/EU to Switzerland had developed below the average increase for total trade. The TMR of exports to Switzerland had
even decreased (minus 18%) from 1976 to 2000, indicating a positive development towards decoupling of resource use from value gained by exports to Switzerland in the EU. Most obvious increases of exports from 1976 to 2000, however, were observed for trade of the EC/EU with Chile (plus 949% of physical exports), and China (plus 1654% of TMR of exports and plus 2132% of monetary exports). Monetary exports of the EC/EU to e.g. Brazil (plus 639%) and India (plus 1067%) had also increased significantly from 1976 to 2000, indicating increasing integration of these economies in the global market. The nature of their trade relations with the EU could be investigated in future studies.

Most expensive imports of the EU-15 in 2000 came from East Asian economies, Hong Kong, Japan and China, and from Switzerland. Japan and Hong Kong also received most expensive exports from the EU in 2000, besides Australia, South Africa and the U.A. Emirates. Among these countries, trade of the EU in 2000 with Hong Kong, Japan and Switzerland was characterized by especially high ratios of import prices to export prices. However, only the monetary trade balance with Japan was positive, indicating net gains of Japan by trade with the EU. Contrary, despite of relatively high import over export prices, the EU still achieved net gains from trade with Hong Kong and Switzerland in 2000. Whereas Japan had increased its monetary surplus from trade with the EC/EU from 1976 to 2000 by as much as 1054%, Hong Kong had moved from a net gain in 1976 to a net deficit in 2000, and Switzerland had increased its deficit from 1976 to 2000 by 158%.

The physical trade balance of the EU-15 in 2000 shows that net direct resource requirements of the EU were mainly acquired in Russia, Norway, secret countries, Brazil, and Saudi Arabia, indicating that requirements for fossil fuels and minerals were main drivers for the PTB of commodities of the EU. The PTB of the EC/EU with Norway and Brazil was increasing from 1976 to 2000, due to enhanced sourcing of fossil fuels and metals, whereas the PTB with Saudi Arabia declined during the same period due to reduced oil imports of the EU and a shift towards sourcing fossil fuels from European regions.

Net total material resource requirements (PTB TMR) of the EU-15 in 2000 were mainly located in Brazil, Australia, Russia, South Africa, and China, indicating highly resource intensive acquisition of the EU of metals, minerals and fossil fuels in these countries. In addition, the physical trade balance for TMR with these countries with the EC/EU had even increased from 1976 to 2000, indicating increasing requirement of the EU of these highly resource intensive commodities in particular from newly industrializing economies. Australia is an exception because of its huge reserves of mineral resources (especially bauxite) leading to high exports of raw materials – a rather untypical situation for a developed economy.
Table 44: Foreign trade parameters of the EU-15 in 2000 and their changes versus 1976: for single countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Imports absolute</th>
<th>% Change vs. 1976</th>
<th>Exports absolute</th>
<th>% Change vs. 1976</th>
<th>Imports-Exports</th>
<th>% Change vs. 1976</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>1.106</td>
<td>32%</td>
<td>6.259</td>
<td>114%</td>
<td>51%</td>
<td>59%</td>
</tr>
<tr>
<td>Andorra</td>
<td>2.100</td>
<td>9.0%</td>
<td>51.0</td>
<td>3%</td>
<td>31%</td>
<td>155%</td>
</tr>
<tr>
<td>Australia</td>
<td>2.100</td>
<td>9.0%</td>
<td>51.0</td>
<td>3%</td>
<td>31%</td>
<td>155%</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.85%</td>
<td>5.0%</td>
<td>114%</td>
<td>1.2%</td>
<td>9.0%</td>
<td>3%</td>
</tr>
<tr>
<td>Canada</td>
<td>1.106</td>
<td>32%</td>
<td>6.259</td>
<td>114%</td>
<td>51%</td>
<td>59%</td>
</tr>
<tr>
<td>China</td>
<td>3.85%</td>
<td>5.0%</td>
<td>114%</td>
<td>1.2%</td>
<td>9.0%</td>
<td>3%</td>
</tr>
<tr>
<td>Chile</td>
<td>1.106</td>
<td>32%</td>
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Note: #DIV/0! = value in 1976 is zero.

Imports of trade goods

The relevance of import commodities which cannot, or only to a small extent, be produced domestically within the EC/EU was also investigated in this study. These products are not or only at small amounts available within the natural production system of the EC/EU. To replace them by domestic products, considerable efforts are required to develop technologies.
for supply, production and consumption. In this context, only raw materials like coffee, cocoa beans, cotton, all ores, fossil fuels (which stem by about half of the domestic demand from imports), or rare minerals. The availability of these raw materials is limited due to natural circumstances in the EC/EU. The may be substitutes to a significant extent on the medium or long term by new technologies – also by using alternative raw materials (e.g. by regrowing raw- and fuel materials, especially however by efficiency technologies). A dependency on imports of these raw materials can therefore only be assumed on the basis of existing technologies. For simplicity these raw materials are here named trade goods.

In 2000, 892 million tonnes of trade goods were imported by the EU, 28% more than in 1976 (Figure 11). This represented 85% of all raw material imports, a share that remained relatively constant during 1976 to 2000. Therefore, the largest part of raw material imports of the EC/EU is meant to cover the actual requirement for resources which are not available domestically, respectively not at sufficient amounts available to satisfy the given demand. Most of these trade goods came in 2000 from the rest of Europe (29%), followed by Africa (22%), Asia and America with 18% each of total imports. From 1976 to 2000 the share of imports of trade goods by the EC/EU from other European countries had increased from 13% to 29%, whereas the share of imports of trade goods from Asia had decreased from 50% to 18%, mainly as a consequence of reduced imports of mineral fuels. The contributions of Africa and America were rather fluctuating from 1976 to 2000 between 20-30% for Africa and 10-24% for America. Oceania played only a minor role with shares of 3-7%.

The biggest part of these trade goods came from developing countries outside Europe (74-46%, with clearly declining tendency and also with decreasing absolute amounts), 14-32% came from OECD countries with fluctuating tendency. Imports of trade goods from newly industrializing countries (NIC) in Europe were of increasing importance, from 9% in 1976 to 17% in 2000. Severely indebted countries (SIC) delivered relatively constant and high amounts of trade goods to the EC/EU at around 20%. NIC in Europe – besides severely indebted countries – more and more took over the function of delivering raw materials which cannot or only to a not sufficient extent be produced within the EU economy. Contrary, the shares of trade goods to the EC/EU from low income countries (LIC), highly indebted poor countries (HIPC), and from sub-saharan Africa are much lower at around 3-11% and the tendency is rather declining since 1976.
Figure 11: Imports of trade goods to the EC/EU 1976-2000.

Note: Others: not specified, e.g. secret data; HIPC = highly indebted poor countries; LDC = least developed countries; LIC = low income countries; SIC = severely indebted countries; NIC Europe = Newly Industrializing Countries in Europe; DC = Developing Countries outside Europe.

Sources: Eurostat Comext 2001 and own calculations.
Imports of pollution intensive commodities

Ecological implications can be evaluated through the quantitative analysis of pollution intensive goods. Based on a study of the World Bank (Mani and Wheeler 1997) ten commodity groups of the most pollution intensive sectors can be identified: iron and steel, non-ferrous metals, chemicals (industrial- and other chemicals), mineral fuels, mineral non-metallic products, pulp and paper, rubber products, leather products, and metal products. These commodity groups comprise raw materials as well as semi-manufactured and finished products. The criterion “pollution intensive” is based on environmental pressure caused by emissions to air, emissions to water, and emissions of heavy metals which are combined for an overall ranking of most polluting sectors. Measurement of the pollution intensity of the sectors is based on two parameters: (1) abatement expenditures per unit output in the U.S. and other OECD economies, and (2) actual emission intensities (emissions per unit output) for US manufacturing sectors. The results of pollution intensity of sectors from these two parameters are compared and integrated to an overall characterization of pollution intensive production (for more details and references on this procedure see Mani and Wheeler 1997).

Environmental pressures associated with the import of pollution intensive commodities can be allocated to the region producing these commodities if the environmental impact is emission relevant for production. This is in principle the case for all pollution intensive commodity groups. Mineral fuels constitute an exceptional case because their use by combustion in the region of destination causes major environmental problems on a global scale. Therefore, pollution intensive commodities were differentiated here into two groups, i.e. all pollution intensive goods (Figure 12), and pollution intensive goods excluding mineral fuels to indicate environmental pressure exerted primarily on the territories of the producing countries that export to the EC/EU (Figure 13). Still, the specific intensity of environmental pressure can be very different on a global scale because of e.g. differences in technologies (e.g. filters, end-of-pipe solutions), and the absolute distribution of the real environmental pressure may vary accordingly. Differentiated analysis should therefore be further performed in order to evaluate specific environmental burdens in the economies concerned.

From 1976 to 2000 the EC/EU imported increasing amounts of pollution intensive commodities (Figure 12). In 2000 this import was 991 million tonnes (164 million tonnes without mineral fuels), about 50% more than in 1976 (180% more without mineral fuels). The share of pollution intensive commodities represents in total 63-72% of all commodities imported by the EC/EU. Most of these pollution intensive commodities came in 2000 from
the rest of Europe (37%), followed by Asia (21%), Africa (20%), and America with 12% of total imports. From 1976 to 2000 the share of imports of pollution intensive commodities by the EC/EU from other European countries had increased from 15% to 37%, whereas the share of these imports from Asia had decreased from 58% to 21%, mainly as a consequence of reduced imports of mineral fuels – a similar picture as for trade goods. The contributions of Africa and America were rather fluctuating from 1976 to 2000 between 18-29% for Africa and 6-17% for America. Oceania played only a minor role with shares of 1-3%.

A big part of pollution intensive commodities came in 2000 from developing countries outside Europe (41%), however, their share had declined strongly since 1976 when it was 73%, and even the absolute amounts had declined from 480 million tonnes in 1976 to 400 million tonnes in 2000. OECD countries held the second largest share of 30% in 2000 with strongly increasing tendency since 1974 when it was 14%. The same result can be observed for NIC in Europe which had a share of 24% of all imports of the EU of pollution intensive commodities in 2000, starting from 11% in 1976. Obviously, developing countries outside Europe had lost production shares for „dirty industries“ goods for the export market to the EU. However, NIC outside Europe showed a different development, they increased their share of pollution intensive imports of the EC/EU from 8% in 1976 to 15% in 2000.

From 1976 to 2000 the EC/EU imported also increasing amounts of pollution intensive commodities excluding mineral fuels (Figure 13). In 2000 this import was 164 million tonnes, about 180% more than in 1976. These imports had increased relatively more than the imports of all pollution intensive goods (50%). The share of pollution intensive commodities excluding mineral fuels represents in total 6-11% of all commodities imported by the EC/EU, with clearly increasing trend from 1976 (6%) to 2000 (11%). Most of these pollution intensive commodities came in 2000 from the rest of Europe (53%), followed by Asia (19%), America (19%), and Africa with 7% of total imports. From 1976 to 2000 the share of imports of pollution intensive commodities excluding mineral fuels by the EC/EU from other European countries had fluctuated from 51% to 65%, whereas the share of these imports from Asia had increased from about 10% to 19%. The contributions of Africa and America were rather fluctuating from 1976 to 2000 between 5-8% for Africa and 17-27% for America. Oceania played only a minor role with shares of 1-3%.

The biggest part of pollution intensive commodities excluding mineral fuels came in 2000 from OECD countries (49%) and newly industrializing countries in Europe (41%). Whereas the share of OECD countries had decreased from 70% in 1976 (but absolute amounts had
increased from 41 million tonnes 1976 to 81 million tonnes 2000), the share of newly industrializing countries in Europe had increased strongly from 16% in 1976 to 41% in 2000 (i.e. from 9 million tonnes 1976 to 67 million tonnes 2000). Developing countries outside Europe contributed also a large share of 27% in 2000, their share had increased since 1976 when it was only 13%, and the absolute amounts had increased from 8 million tonnes in 1976 to 45 million tonnes in 2000. Obviously, newly industrializing countries in Europe and developing countries outside Europe produced increasingly „dirty industries“ goods for the export market to the EU, especially since the middle of the 90s. This development coincides with the period of accelerated globalization of the international economy (Enquete Commission 2002). Also, NIC outside Europe showed a similar though less expressed development at lower absolute levels, they increased their share of pollution intensive imports of the EC/EU from 7% in 1976 to 16% in 2000.

These results lead to the question whether environmental pressure intensive production through emissions and wastes has been increasingly shifted to developing countries outside Europe and especially to newly industrializing countries in Europe, i.e. mainly to Eastern Europe. In this study only the absolute increase of these imports could be observed. If this increase of imports was in line with a shift of pollution intensive production to foreign countries due to a decline of domestic production capacities in the EU could only be investigated by comparative analysis of domestic production data for these pollution intensive sectors. This could be potentially subject of further studies.
Figure 12: Imports of all pollution intensive commodities to the EC/EU 1976-2000.

Note: Others: not specified, e.g. secret data; HIPC = highly indebted poor countries; LDC = least developed countries; LIC = low income countries; SIC = severely indebted countries; NIC Europe = Newly Industrializing Countries in Europe; NIC outside Europe = Newly Industrializing Countries outside Europe; DC = Developing Countries outside Europe.

Sources: Eurostat Comext 2001 and own calculations.
Figure 13: Imports of pollution intensive commodities excluding mineral fuels to the EC/EU 1976-2000.

Note: Others: not specified, e.g. secret data; HIPC = highly indebted poor countries; LDC = least developed countries; LIC = low income countries; SIC = severely indebted countries; NIC Europe = Newly Industrializing Countries in Europe; NIC outside Europe = Newly Industrializing Countries outside Europe; DC = Developing Countries outside Europe.

Sources: Eurostat Comext 2001 and own calculations.
3.3. *Analysis of land use for imports, exports and domestic consumption of agricultural commodities of the EU.*

The extent and distribution of land use for imports and exports of agricultural commodities of the EU was evaluated, broken down by material categories (e.g. coffee, fruits, vegetables, fibres) and economic regions, country groupings and national economies as referred to in chapter 3.2. The database of FAOSTAT for yields of agricultural primary commodities was used to account for land use in combination with the physical imports and exports data from the Eurostat COMEXT database. In addition, land use coefficients for agricultural plant products (e.g. milling products) and agricultural animal products (e.g. meat) available in the database of the Wuppertal Institute were applied to derive total land use estimates associated with all imported and exported agricultural commodities. Variations of land requirements for agricultural imports, exports and the resulting balances over time and by regional distribution were investigated, in order to evaluate the magnitude and relative change of the dependency of the EU on foreign agricultural land resources and its role in providing agricultural land by exports to other regions. Furthermore, the land use required for domestic consumption of agricultural products in the EU was evaluated (derived from domestically available agricultural land plus land use associated to imports minus exports associated land use). The result shows to which extent the EU requires more or less land for its consumption of agricultural products than is available within the region. Further, the absolute level of land use per capita of the EU demonstrates how much this requirement is above or below the global average of available agricultural land.

The data on which this chapter on land use is based were largely elaborated by Sören Steger, Wuppertal Institute (Steger 2003).

**Land use for imports and exports – overview**

From 1990 to 2000 the EC/EU required a rather constant amount of agricultural land abroad for its imports of related commodities, which ranged between 41 and 48 million hectares (Figure 14). Land use for exports of agricultural commodities was at a much lower level but with slightly increasing tendency from 14 to 18 million ha over the same period (by about 17%). Consequently, the net agricultural land use by foreign trade of the EC/EU declined (by about 18%) from 31 to 25 million ha from 1990 to 2000.
From 1990 to 2000, imports of agricultural commodities by the EC/EU required on average increasingly less land use. In 1990, 0.53 ha were required for the import of 1 ton of agricultural commodities. This specific ratio declined by 16% to 0.44 ha per ton in 2000. The specific land requirement in 1990 for exports of agricultural commodities of the EC/EU (0.28 ha per ton) was only about half of that for imports, and it declined as well by about 9% until 2000. Specific land use requirements for net imports (balance) showed rather a fluctuating course between 0.69 and 0.98 ha per t over the period.

Figure 14: Agricultural land use by imports and exports of the EC/EU 1990-2000.

Land use for imports and exports by materials

Land use for imports and exports was differentiated by three major material groups of agricultural commodities: primary crops (equivalent to domestic harvest), plant products (manufactures from plants harvested like beer), and animal products (of agricultural origin like cow milk). These three groups comprised in total 149 single commodities (47 primary crops, 69 plant products, and 33 animal products), and were in line with the commodities differentiated by the Eurostat methodological guide on economy-wide MFA (Eurostat 2001).

Land use for imports by the EC/EU was about to the same extent dominated by primary crops and plant products (Figure 15), but primary crops ranged slightly over plant products in the EU-15 whereas the opposite situation was observed for the EC-12. Land use related to imports of animal products contributed only about 7% to the total in 2000, and had remained rather constant from 1990 to 2000.
Land use for exports of agricultural commodities of the EC/EU was more evenly distributed among the three major commodity groups than for imports. In 2000, land use related to exports of plant products stood for about 45% of the total, land use for primary crops for about 34%, and land use for animal products for about 20% (Figure 15). However, the trends from 1990 to 2000 were different. Land use related to exports of animal products had increased over that period by 29%, but most of that increase happened from 1990 to 1991 and afterwards the overall increase was rather based on fluctuating high levels from 1991 to 2000. Land use for exports of plant products increased by 22% from 1990 to 2000, but mostly because of a stepwise increase from EC-12 to EU-15 in 1994 to 1995, remaining more or less on the same high level until 2000. Land use related to exports of primary crops showed a strongly fluctuating course from 1990 to 2000 with a small overall change of plus 5%. So, the overall increase of land use related to exports of agricultural commodities of the EC/EU was largely mediated by exports of plant products and animal products. The overall balance of land use related to imports and exports, which had declined from 1990 to 2000 by 18% or 5 million ha, was also dominated by primary crops and plant products, showing diverging trends due to the step from EC-12 to EU-15 in 1994 to 1995. The EU-15 in 1995 had required abroad more net land for primary crops but less net land for plant products than the EC-12 in 1994. On the other hand, the EU-15 from 1995 to 2000 had always provided more land for exports of animal products than it required for the corresponding imports. This balance had rather been changeable in EC-12 between net import surpluses and vice versa.

To sum up, the EU-15 from 1995 to 2000 constantly required considerably more agricultural land (about 3 times more) for its imports than it provided to the rest of the world via exports of agricultural commodities. This was not only due to higher absolute amounts of physical imports but also due to higher specific land requirements for imported commodities than for exports. Changes of land use related import and export parameters over the period showed rather fluctuating trends at low variations. The net surplus of land requirement by imports was mainly due to raw materials and derived products demand for production and consumption. Contrary, the EU from 1995 to 2000 had always provided more land for (direct) exports of animal products than it required for imports, indicating the high economic relevance of animal production in the EU.
The major agricultural commodities contributing to land use requirements by imports of the EC/EU are shown in Figure 16 (derived from a selection under 149 commodities contributing 3% and more to the total land use by imports; only the dominant materials among these are shown in the legend). These were especially oilcakes for animal feed, oilcrops (soybeans, sunflower seed) for plant oil production, as well as coffee beans and cocoa beans for manufacturing of derived products. Primary agricultural commodities for direct consumption (like fruits, vegetables) obviously play only a minor role for the overall extent of land use required for imports.

The major agricultural commodities contributing to land use requirements by exports of the EC/EU are shown in Figure 17 (derived from a selection under 149 commodities contributing
3% and more to the total land use by exports; only the dominant materials among these are shown in the legend). These were especially cereals (wheat, barley), plant oils and fats, sugar, and meat and dairy products. This exports land use pattern mirrors largely the distribution of land use by commodity imports in showing the high relevance of derived products from oilseeds and animal feed. But also domestic primary crops like cereals as direct exports and sugar beets for production and export of sugar play significant roles in this context.

**Figure 17: Major commodities for land use by exports of the EC/EU 1990-2000.**

The major agricultural commodities contributing to net land use requirements by foreign trade of agricultural commodities of the EC/EU are shown in Figure 18 (derived from a selection under 149 commodities contributing ±3% and more to the total net land use; only the dominant materials among these are shown in the legend). The distribution of net land use for imports underlines the high relevance of commodities for processing and animal production as described before. Obviously, the low amount of net land use for exports of the EC/EU is linked to the dominance of high yielding crops and derived products like cereals, oilseeds and sugar beets.
Land use for imports and exports by regions and countries

Land use related to imports and exports of agricultural commodities of the EC/EU 1990 to 2000 was studied by the same classifications for economies as for monetary and physical trade flows described in chapter 3.2.

Land use by income classes and level of external debt

Land use related to agricultural imports of the EU-15 in 2000 was mostly located in middle income countries, but low income countries (LIC) also carried a high share of almost one quarter, more than high income OECD countries with 20% (Table 45). A remarkable high share is allocated to severely indebted countries (SIC). In 2000, about half (47%) of the agricultural land associated with all imported agricultural commodities by the EU-15 was located in severely indebted countries. This finding clearly underlines results for material requirements (of all materials, not only agricultural ones) indicating that economies with high external debts can be characterized as countries providing especially resource intensive commodities for export to industrial economies. Indebtedness obviously leads to increased pressure on domestic resources in order to achieve income by foreign trade. Also heavily indebted poor countries (HIPC) held a relatively high share of land use for imports of the EU-15 in 2000 at 14% of the total. Whereas total land use for imports of agricultural commodities had declined by 7% from 1990 to 2000, the contributions by poor countries (LIC) had decreased more significantly (by 22%). The shares of SIC and HIPC had declined at similar rates as for total imports. The reasons for these developments would require further analysis.
Almost two thirds (64%) of the land use associated with agricultural exports of the EU-15 in 2000 was related to exports to middle income countries. The shares of poor and indebted countries are lower than for imports, however, they are still significant at 13% for LIC, 13% for SIC and 8% for HIPC, similar to the extent of land use related to exports to high income OECD countries at 15%. Furthermore, as compared with the average increase of land use for exports of agricultural commodities from 1990 to 2000 (17%), especially land use related to exports to LIC had increased with 49% much above the average, and similar observations were made for SIC (plus 17%) and HIPC (plus 37%). Only land use for exports to upper middle income countries had increased significantly more by 75%, whereas land use related to exports to lower middle income countries had even decreased over this period by 13%. In how far this might be due to increasing food aid given by the EU to poor countries would require further specific analysis.

Net land use (balance) resulting from foreign trade with agricultural commodities of the EU-15 in 2000 showed a similar distribution as observed for land use related to imports. Most remarkable is the high share of net land requirement in severely indebted countries at 71% of the total. This underlines the finding that high foreign indebtedness leads to high natural resource use and adds to this that economies with high foreign debts are increasingly net providers of natural resources to high income industrial economies.

Table 45: Agricultural land use related to foreign trade of the EC/EU 1990-2000 with economies classified by income and external debt.

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<td>1%</td>
<td>36%</td>
<td>1,280</td>
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<td>40%</td>
<td>-1,049</td>
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<td>40%</td>
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<td>25%</td>
<td>6,052</td>
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<td>17%</td>
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<td>8%</td>
<td>37%</td>
<td>4,357</td>
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Land use by developing countries and newly industrializing countries

Land use related to agricultural imports of the EU-15 in 2000 was to a large extent (by 67%) located in developing countries outside Europe (DC) and among DC to a large extent in newly industrializing economies (47%) (Table 46). Newly industrializing countries (NIC) in Europe including the former centrally planned economies (CPE) provided 12% of the
agricultural land required by the EU-15 in 2000 for its imports of agricultural commodities. Land use located in least developed countries (LDC) was at 5% of the total in 2000 of minor relevance.

Similarly, agricultural land provided by the EU-15 in 2000 through its exports of agricultural commodities to other economies was mostly for developing countries outside Europe (57%), and only to a small extent for least developed countries (LDC = 8%). In contrast to imports, land use for exports of the EU was at a higher share related to NIC in Europe (26%) than to NIC outside Europe (11%).

With all these developing economies, the EU-15 in 2000 had a positive land use balance, i.e. additional agricultural land was required abroad for the foreign trade of agricultural commodities. Again, this additional land was especially located in developing countries outside Europe (75%) and in particular in newly industrializing economies there (72%).

However, the development of land use for agricultural commodities by imports of the EC/EU showed a clear trend towards less land use in developing countries outside Europe, including NIC and LDC, but towards more land use in the newly industrializing economies in Europe. As the total land use associated with agricultural imports had declined only by 7% from 1990 to 2000, this represents a clear shift of land use requirements from DC outside Europe to NIC in Europe. Still, as described before DC held a much larger absolute share of land use requirements of the EU-15 in 2000 than NIC in Europe.

Land use provided by the EC/EU to other economies through agricultural exports had increased with regards to all economies classified by development, and most for newly industrializing economies outside Europe (plus 44% from 1990 to 2000). Decreasing land use for imports and increasing land use for exports had led to a decrease of the net land use (balance) for agricultural commodities of the EC/EU in developing countries, including NIC and LDC. The change of the land use balance for NIC in Europe is rather arbitrary because net surplus land requirements by imports were only found for 2000, 1996 and 1994, whereas for 1990 and the remaining years in between the net land use was negative, i.e. land use for exports by the EC/EU to NIC in Europe was higher than vice versa.

The results for agricultural land use indicate once more the overall high relevance of developing countries outside Europe in terms of natural resource requirements of the EU through foreign trade, although this relevance appears to be declining most probably due to a shift towards newly industrializing countries in Europe. This observation points to a probably lower foreign land use requirement abroad in an extended EU-25 and beyond. This should be
a matter of further monitoring and more specific studies. Another remarkable result is the relatively high land use requirement of the EU for agricultural commodities in newly industrializing countries outside Europe. This may be a hint that new industrial development in these economies is largely based on natural resource intensive sectors like agriculture in this case. An impressive evidence for this hypothesis represents the development in Chile since 1973 (Giljum 2002). With increasing integration into the world market, Chile had diversified its economy also by the expansion of fruit plantation, forestry and fishery, mainly for exports, in the end only contributing to an expansion of natural resource intensive sectors.

Table 46: Agricultural land use related to foreign trade of the EC/EU 1990-2000 with economies classified by development.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>42,806</td>
<td>100%</td>
<td>-7%</td>
<td>17,521</td>
<td>100%</td>
<td>17%</td>
<td>25,285</td>
<td>100%</td>
<td>-18%</td>
</tr>
<tr>
<td>Developing countries outside Europe</td>
<td>28,790</td>
<td>67%</td>
<td>-17%</td>
<td>9,946</td>
<td>57%</td>
<td>13%</td>
<td>18,844</td>
<td>75%</td>
<td>-27%</td>
</tr>
<tr>
<td>Least developed countries</td>
<td>2,148</td>
<td>5%</td>
<td>-36%</td>
<td>1,326</td>
<td>8%</td>
<td>23%</td>
<td>823</td>
<td>3%</td>
<td>-64%</td>
</tr>
<tr>
<td>Newly Industrial(ized) Countries (NIC) or Emerging Markets outside Europe</td>
<td>20,097</td>
<td>47%</td>
<td>-18%</td>
<td>1,934</td>
<td>11%</td>
<td>44%</td>
<td>18,163</td>
<td>72%</td>
<td>-21%</td>
</tr>
<tr>
<td>NIC Europe incl. CPE</td>
<td>5,104</td>
<td>12%</td>
<td>141%</td>
<td>4,567</td>
<td>26%</td>
<td>25%</td>
<td>537</td>
<td>2%</td>
<td>-135%</td>
</tr>
</tbody>
</table>

Land use by geographical regions

Land use related to agricultural imports of the EU-15 in 2000 was mostly located in Latin America by 38% of the total (Table 47). This underlines the relatively high importance of Latin America, like for material resource requirements, as region providing natural resources for imports by the EU. Next important was land use for imports from North America (16%), and Western Africa and East Asia with 9% each. Most significant increases, however, were found for land use required by imports of the EU in Central and Eastern Europe, as well as in North Africa. At rather constant overall land use requirements for agricultural imports, the EU had increasingly shifted part of its requirements for land use from America, Asia, and Sub-saharan Africa to Central and Eastern Europe and North Africa. Still, America and Asia were by far bigger contributors to land use by imports of the EU in 2000 than the regions with highest rates of increase.

Land use related to exports of agricultural commodities of the EU-15 in 2000 was more evenly distributed among regions as observed for imports. The main destinations for exports land use were North Africa (18%), The Middle East (17%), East Asia (10%), Central and Eastern Europe (10%) and the rest of Western Europe (9%). Thus, the EU provides
agricultural land by exports especially to those regions with relative shortage in agricultural land availability on their own territory, i.e. North Africa and The Middle East. In general, land use for imports is strongly located in the West whereas land use for exports is mostly destined to the South and East. Most remarkable increases of land use related to agricultural exports of the EC/EU were however found for other than the main regions in 2000, i.e. for Western Africa and West Asia. On the other hand, land use for exports to Central and Eastern Europe and Latin America had decreased significantly from 1990 to 2000.

Net land use use (balance) resulting from foreign trade with agricultural commodities of the EU-15 in 2000 showed a similar distribution as observed for land use related to imports. Most remarkable is the high share of net land requirement in Latin America, in line with the results found for severely indebted countries obviously located there. Among the 15 regions studied, only four were found to have a negative land use balance for trade with the EU. These were the rest of Western Europe, the Baltic States, North Africa, and The Middle East, i.e. regions that require significant agricultural land by imports from the EU.

Table 47: Agricultural land use related to foreign trade of the EC/EU 1990-2000 by geographical regions.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Imports 2000 000 ha</th>
<th>2000 %</th>
<th>2000 % change vs. 1990</th>
<th>Exports 2000 000 ha</th>
<th>2000 %</th>
<th>2000 % change vs. 1990</th>
<th>Balance 2000 000 ha</th>
<th>2000 %</th>
<th>2000 % change vs. 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>42,806 100%</td>
<td>-7%</td>
<td>17,521 100%</td>
<td>17%</td>
<td>25,285 100%</td>
<td>-18%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>6,732 16%</td>
<td>-6%</td>
<td>1,282 7%</td>
<td>16%</td>
<td>5,450 22%</td>
<td>-10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>16,080 38%</td>
<td>-4%</td>
<td>788 4%</td>
<td>-22%</td>
<td>15,292 60%</td>
<td>-3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Europe excl. EUR</td>
<td>774 2%</td>
<td>-1%</td>
<td>1,619 9%</td>
<td>12%</td>
<td>845 -3%</td>
<td>28%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central and Eastern Europe</td>
<td>2,407 6%</td>
<td>45%</td>
<td>1,824 10%</td>
<td>-36%</td>
<td>583 2%</td>
<td>-149%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baltic States</td>
<td>193 0%</td>
<td></td>
<td>341 2%</td>
<td></td>
<td>-148</td>
<td>-1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commonwealth of Independent States (transition economies)</td>
<td>2,015 5%</td>
<td></td>
<td>1,565 9%</td>
<td></td>
<td>450 2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Africa</td>
<td>490 1%</td>
<td>38%</td>
<td>3,067 18%</td>
<td>14%</td>
<td>-2,578 -10%</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Africa</td>
<td>3,829 9%</td>
<td>5%</td>
<td>833 5%</td>
<td>85%</td>
<td>2,996 12%</td>
<td>-6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central Africa</td>
<td>891 2%</td>
<td>-31%</td>
<td>337 2%</td>
<td>20%</td>
<td>555 2%</td>
<td>-46%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Africa</td>
<td>1,069 2%</td>
<td>-38%</td>
<td>329 2%</td>
<td>-6%</td>
<td>740 3%</td>
<td>-46%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Africa</td>
<td>522 1%</td>
<td>-50%</td>
<td>244 1%</td>
<td>-6%</td>
<td>278 1%</td>
<td>-64%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Middle East</td>
<td>173 0%</td>
<td>-39%</td>
<td>2,989 17%</td>
<td>18%</td>
<td>-2,816 -11%</td>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Asia</td>
<td>1,671 4%</td>
<td>-63%</td>
<td>367 2%</td>
<td>64%</td>
<td>1,304 5%</td>
<td>-70%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Asia</td>
<td>3,977 9%</td>
<td>-18%</td>
<td>1,794 10%</td>
<td>17%</td>
<td>2,183 9%</td>
<td>-34%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oceania</td>
<td>2,003 5%</td>
<td>16%</td>
<td>137 1%</td>
<td>15%</td>
<td>1,865 7%</td>
<td>16%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geographical: missing</td>
<td>-20 0%</td>
<td>-180%</td>
<td>3 0%</td>
<td>-88%</td>
<td>-23 0%</td>
<td>1649%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Land use by economic regions

Land use related to agricultural imports of the EU-15 in 2000 was mainly located in MERCOSUR and APEC economies, both ranging above land use for imports from OECD countries (Table 48). This result underlines once more the high relevance of Latin America for natural resource use of the EU.
Agricultural land provided by the EU-15 in 2000 by exports of agricultural commodities was mainly for OECD countries, APEC economies, countries of the MEDITERRANEAN BASIN and OPEC economies. This reflects obviously intensive trade connections (OECD, APEC) as well as land provision for regions with presumably rather low availability of agricultural land on their own territories (MEDITERRANEAN BASIN, OPEC). The latter assumption is further supported by the finding that the EU provided significantly more agricultural land to the OECD and MEDITERRANEAN BASIN than it required by imports (negative balance). A similar situation was found in addition only for EFTA countries and European OECD countries. For all the other economic regions studied the land use balance of the EU-15 in 2000 was positive and most net agricultural land was required in the MERCOSUR confirming the above cited result for Latin America’s importance as provider of natural resources to the EU.

This relevance of MERCOSUR had however declined from 1990 to 2000 as regards land use for imports and even more as regards land use for exports. Contrary, agricultural land use associated with imports and exports of agricultural commodities of the EC/EU had increased most from 1990 to 2000 for trade with European OECD countries and Candidate Countries of the EU. The latter finding underlines the increasing relevance of especially Eastern European countries as trade partners of the EU in terms of natural resources during the 1990s.

### Table 48: Agricultural land use related to foreign trade of the EC/EU 1990-2000 by economic regions.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Imports 2000 000 ha</th>
<th>%</th>
<th>% change vs. 1990</th>
<th>Exports 2000 000 ha</th>
<th>%</th>
<th>% change vs. 1990</th>
<th>Balance 2000 000 ha</th>
<th>%</th>
<th>% change vs. 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total trade</td>
<td>42.806</td>
<td>100%</td>
<td>-7%</td>
<td>17.521</td>
<td>100%</td>
<td>17%</td>
<td>25.285</td>
<td>100%</td>
<td>-18%</td>
</tr>
<tr>
<td>ACP</td>
<td>6.718</td>
<td>16%</td>
<td>-16%</td>
<td>1.811</td>
<td>10%</td>
<td>27%</td>
<td>4.908</td>
<td>19%</td>
<td>-25%</td>
</tr>
<tr>
<td>MED. BASSIN</td>
<td>1.056</td>
<td>2%</td>
<td>22%</td>
<td>4.015</td>
<td>23%</td>
<td>6%</td>
<td>-2.959</td>
<td>-12%</td>
<td>1%</td>
</tr>
<tr>
<td>OPEC</td>
<td>1.088</td>
<td>3%</td>
<td>-18%</td>
<td>3.409</td>
<td>19%</td>
<td>16%</td>
<td>-2.320</td>
<td>-9%</td>
<td>43%</td>
</tr>
<tr>
<td>ASEAN</td>
<td>3.343</td>
<td>8%</td>
<td>-14%</td>
<td>386</td>
<td>2%</td>
<td>80%</td>
<td>2.957</td>
<td>12%</td>
<td>-20%</td>
</tr>
<tr>
<td>CANDIDATE COUNTRIES</td>
<td>3.020</td>
<td>7%</td>
<td>78%</td>
<td>2.838</td>
<td>16%</td>
<td>90%</td>
<td>183</td>
<td>1%</td>
<td>-12%</td>
</tr>
<tr>
<td>NAFTA</td>
<td>6.935</td>
<td>16%</td>
<td>-5%</td>
<td>1.344</td>
<td>8%</td>
<td>1%</td>
<td>5.591</td>
<td>22%</td>
<td>-7%</td>
</tr>
<tr>
<td>MERCOSUR</td>
<td>14.344</td>
<td>34%</td>
<td>-6%</td>
<td>115</td>
<td>1%</td>
<td>-28%</td>
<td>14.229</td>
<td>56%</td>
<td>-6%</td>
</tr>
<tr>
<td>APEC</td>
<td>13.874</td>
<td>32%</td>
<td>-0%</td>
<td>4.422</td>
<td>25%</td>
<td>53%</td>
<td>9.453</td>
<td>37%</td>
<td>-14%</td>
</tr>
<tr>
<td>OECD excl. Europe</td>
<td>8.709</td>
<td>20%</td>
<td>-1%</td>
<td>2.087</td>
<td>12%</td>
<td>19%</td>
<td>6.623</td>
<td>26%</td>
<td>-6%</td>
</tr>
<tr>
<td>OECD</td>
<td>11.248</td>
<td>26%</td>
<td>7%</td>
<td>4.846</td>
<td>28%</td>
<td>46%</td>
<td>6.402</td>
<td>25%</td>
<td>-11%</td>
</tr>
<tr>
<td>Major seven</td>
<td>6.730</td>
<td>16%</td>
<td>-6%</td>
<td>1.663</td>
<td>9%</td>
<td>30%</td>
<td>5.068</td>
<td>20%</td>
<td>-14%</td>
</tr>
<tr>
<td>OECD-Europe</td>
<td>2.539</td>
<td>6%</td>
<td>53%</td>
<td>2.760</td>
<td>16%</td>
<td>77%</td>
<td>-221</td>
<td>-1%</td>
<td>-307%</td>
</tr>
<tr>
<td>EFTA</td>
<td>242</td>
<td>1%</td>
<td>5%</td>
<td>720</td>
<td>4%</td>
<td>32%</td>
<td>-479</td>
<td>-2%</td>
<td>52%</td>
</tr>
</tbody>
</table>

### Land use by major trade partners

Land use related to agricultural imports of the EU-15 in 2000 was mostly located in Brazil, Argentina, USA, Canada and Ivory Coast (Table 49). However, most expressed changes had occurred for land use in Eastern European countries, in particular in Romania, Ukraine (since
1993), and Russia (since 1993). Russia (position 10) and Ukraine (position 12) ranked also high in terms of absolute land use in 2000. Land use by imports of the EC/EU in Canada was characterized by both high absolute contribution to overall land use in 2000 and high increase from 1990 to 2000 (position 4). Similarly, land use for imports of agricultural commodities in Ghana had increased significantly from 1990 to 2000 (position 5) and had reached position 11 in absolute terms in 2000 among 31 countries with high relevance for either land use for imports or exports of the EC/EU between 1990 and 2000.

The EU-15 provided agricultural land by exports in 2000 especially to Russia, Saudi Arabia, USA, Poland and Morocco. Thus, trade with agricultural commodities with the U.S. is characterized by relatively high land use in both economies. High land use provision of the EU by exports to Saudi Arabia and Morocco may be rather explained by relatively low regional availability of agricultural land per capita in these countries. The high relevance for land use by exports to Russia and Poland shows once more that foreign trade of the EU with the Eastern European countries in transition has gained increasing importance during the 1990s. However, most expressed increases from 1990 to 2000 for land use associated with exports of the EC/EU can be located in Argentina, India, Indonesia, Malaysia and Morocco. So, especially the newly industrializing economies in Asia have increasingly required agricultural land by imports from the EU.

The highest net land use (balance) by foreign trade with agricultural commodities of the EU-15 in 2000 was located in Brazil, followed by Argentina, USA, Canada and Ivory Coast. These economies had provided significantly more agricultural land to the EU than the EU had provided by exports in return. The development of this net land surplus was however different for these top 5 countries. The surplus had especially increased for Canada but also for Argentina and Ivory Coast, whereas net land use had decreased for USA and Brazil.

Contrary, the highest net land provision (balance) by foreign trade with agricultural commodities of the EU-15 in 2000 was for countries in North Africa, i.e. Algeria, Libya, Morocco, and for Saudi Arabia and Japan. Among these, especially net land provision to Morocco, Saudi Arabia and Japan had also increased most among the 31 major trade partners in total.
Table 49: Agricultural land use related to foreign trade of the EC/EU 1990-2000 by major trade partners.

<table>
<thead>
<tr>
<th>Land use for domestic consumption of agricultural commodities</th>
</tr>
</thead>
</table>
| In addition to the agricultural land available in the EC/EU (comprising arable land, permanent crops, permanent pastures), imports of agricultural commodities required about one third of additional agricultural land in foreign countries (Table 50). This relation had remained more or less constant between 1990 and 2000. Contrary, agricultural land used for exports of agricultural commodities to foreign countries was equivalent to about 10-13% of the domestic land for agricultural use, also at relatively constant ratios between 1990 and 2000. The land use estimates for imports are likely to represent rather minimum estimates because they are based, as far as many plant products and all animal products are concerned, on coefficients derived for the German agricultural production. Productivities (yields of field crops and permanent pastures) may, however, be tentatively lower in other regions as compared with Germany. The same may also apply for exports to some extent, as other Member States of the EC/EU are likely to achieve rather lower yields on agricultural land than in Germany. Consequently, the error concerning the balance of imports and exports is likely to be less...
critical, as well as the error concerning land use derived for consumption which is clearly dominated by domestic agricultural land.

Domestic consumption of agricultural goods in the EC/EU required between 17% and 24% more agricultural land than is available on the territory of the EC/EU, with lower ratios of 17-18% found for the EU-15 from 1997 to 2000. As compared with agricultural land available globally, the EC/EU required about 3.4% constantly from 1990 to 2000 for its domestic consumption of agricultural goods. As mentioned before, this is likely to represent a low estimate. A high estimate was based on the assumption that land use of the EC/EU in foreign countries concerns mainly arable land and permanent crop land rather than permanent pastures. This assumption is supported by the result described before, that land use related to imports of animal products contributed only about 7% to the total in 2000, and had remained rather constant from 1990 to 2000. Compared with global arable and permanent crop land (plus permanent pastures in the EC/EU representing a rather favourable rough assumption because land use for net exports cannot be easily deducted), the EC/EU required about 11% at rather constant ratios between 1990 and 2000 for its domestic consumption of agricultural commodities. The following section will put these results into the context of global agricultural land available on the per capita level.

Table 50: Agricultural land use account of the EC/EU 1990-2000 in the global context.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>000 has</td>
<td>B,D,F,I,L,NL,DK,IRL,UK,GR,E,P plus A,FIN,S</td>
<td>EC-12</td>
<td>EU-15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOMESTIC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arable land</td>
<td>71.427</td>
<td>70.706</td>
<td>70.354</td>
<td>69.854</td>
<td>69.253</td>
<td>74.722</td>
<td>75.226</td>
<td>75.160</td>
<td>74.693</td>
<td>74.280</td>
<td>73.763</td>
</tr>
<tr>
<td>Permanent pastures</td>
<td>56.397</td>
<td>53.994</td>
<td>53.900</td>
<td>53.831</td>
<td>54.264</td>
<td>56.932</td>
<td>56.699</td>
<td>56.310</td>
<td>56.592</td>
<td>56.678</td>
<td>56.009</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>139.228</td>
<td>135.892</td>
<td>135.280</td>
<td>134.575</td>
<td>134.387</td>
<td>142.456</td>
<td>142.721</td>
<td>142.365</td>
<td>142.328</td>
<td>142.091</td>
<td>140.964</td>
</tr>
<tr>
<td>IMPORTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural land</td>
<td>45.838</td>
<td>44.090</td>
<td>46.029</td>
<td>44.176</td>
<td>47.687</td>
<td>47.515</td>
<td>43.674</td>
<td>41.181</td>
<td>41.936</td>
<td>43.670</td>
<td>42.806</td>
</tr>
<tr>
<td>% of domestic</td>
<td>32%</td>
<td>32%</td>
<td>34%</td>
<td>33%</td>
<td>35%</td>
<td>35%</td>
<td>31%</td>
<td>29%</td>
<td>29%</td>
<td>31%</td>
<td>30%</td>
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<tr>
<td>EXPORTS</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>% of domestic</td>
<td>11%</td>
<td>11%</td>
<td>12%</td>
<td>12%</td>
<td>11%</td>
<td>12%</td>
<td>10%</td>
<td>12%</td>
<td>12%</td>
<td>13%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Table 50: Agricultural land use account of the EC/EU 1990-2000 in the global context.
Land use of the EC/EU on the global scale

The EC/EU required from 1990 to 2000 between 0.49 and 0.44 hectares agricultural land per capita for the domestic consumption of agricultural goods (Figure 19), with lower and rather declining values for the EU-15 from 1995 to 2000. The worldwide average availability of agricultural land had declined from 0.95 ha per capita in 1990 to 0.83 ha per capita in 2000, the availability of arable land and permanent crops had declined simultaneously over the same period from 0.29 to 0.25 ha per capita.

Compared with the global per capita availability of all agricultural land, the EC/EU had required constantly only 52% to 53% of the global average. However, this calculation includes also permanent pastures which in DC are often at least semi-natural grasslands, not comparable to permanent pastures in Europe. If only arable land and permanent crops are taken as basis for comparison - which reflects the comparability of the area categories in terms of intensity of cultivation - , the land requirements of the EC/EU per capita range even slightly above the global average availability of arable and permanent crops land. In this case, the EU would consume agricultural land close to the global average per capita in 2000.

Projections of the UN, however, expect the global availability of arable land to decrease to 0.17 ha per capita in 2025. The FAO projects that in the next 30 years developing countries will need an additional 120 million ha for crops. This equals about 4.7 times the area that the EU requires currently by net imports of agricultural goods. Considering that there are limits to the further increase of hectare productivity, this would mean that the EU would have to reduce its global land use for consumption of agricultural goods significantly within the next 20 to 30 years in order to leave other countries enough space for their own consumption of food and feed.

As a result, the seeming excess of agricultural land in the EU and Europe has to be put into perspective. The analysis reveals that global land use of the EU is still on average with global availability with regard to food supply. Growing additional requirements for land use, however, e.g. for biofuels, renewable materials, built-up and conservation area will lead to increasing conflicts. Trade-offs between renewable resource supply and land use should be further studied on the basis of comprehensive material and land use accounts, especially with regard to the further development in the ACC. The economy of Eastern European countries is still based to a significant extent on agricultural production. Whereas a short-term adoption of current EU-15 practices would probably lead to a sharp decline of agricultural land use, however, mid-term to long-term requirements of sustainable resource management in Europe may require a continued use of this area, e.g. for sustainable supply with renewables (food
and non-food). Further studies are necessary which consider global land use for the consumption of agricultural commodities in an extended EU, and analyze projections of future land use and resource supply in view of transition of the economies in Eastern Europe and global development trends.

Future studies should further deal with environmental impacts associated with agricultural land use. It is quite obvious that relatively high yields resulting in relatively low land use in economies are due to mostly intensive agricultural farming systems leading empirically to higher environmental pressures than on less intensively cultivated land or on land under controlled organic cultivation which in turn are characterized by relatively high land use. Thus, the mere extent of agricultural land use is certainly not sufficient as an indicator for natural resource use. It should rather be developed towards an indicator expressing the environmental burden associated with agricultural land use, e.g. in terms of mineral fertilizer and pesticides use, soil erosion, soil compression, groundwater pollution, negative effects on biodiversity, or quality of agricultural products. Taking these aspects into account, the agricultural land use of the EU on the global scale may get a significantly higher weight than the mere numbers for land use in hectares tell.

Figure 19: Comparison of agricultural land use of the EC/EU 1990-2000 with global levels.
Conclusions and recommendations

Conclusions and recommendations are provided with regard to the three main parts of this study: (1) methodology development towards economic branch accounts, (2) cross-country analysis of MFA, and (3) globalization and trade of the EU. They are meant to be of use for Eurostat and the Commission.

Methodology development towards economic branch accounts

It can be concluded from this study that comprehensive allocation of economy-wide material inputs and material outputs to economic sectors after the NACE rev.1 classification is feasible. The methodology for allocation of material inputs (and exports of commodities) was developed in this study, comprising aggregation procedures for major material groups oriented towards provision of policy relevant information. Furthermore, a proposal was made for further differentiation of the NACE sectors beyond the 2-digits level in order to point out major actors for material requirements of an economy.

The development of sector accounts for material outputs to the environment shows different levels of feasibility. Sector accounts for emissions to air are commonly well developed, and slight modifications as described in this study are required in order to achieve consistency with the basic concept of economy-wide MFA. Sector accounts for emissions to water need further elaboration, and especially further basic data work to provide this information by environmental statistics in the EU Member States. The same can be concluded for dissipative material outputs to the environment except of the kind related to domestic agricultural production. Sector accounts, as well as basic statistical data, are certainly most critical for final waste disposal and in particular for waste deposition. Here, further basic statistical development is required in order to provide this information EU-wide.

Recommendations to Eurostat:

- Integrate NAMEA-type tables for material inputs to the economy into established and ongoing work on NAMEAs at Eurostat;
- Foster development of sectoral accounts for emissions to water and dissipative material outputs to the environment in Member States in a way which is harmonized and consistent with the economy-wide MFA methodology;
- Further develop the accounts for final waste disposal and waste deposition in a way which is meaningful for the planning and assessment of resource and waste management policies; harmonize accounting of National Statistical Offices;
• Proceed towards comprehensive NAMEAs for material flows as tools for further analysis of sector’s contribution to material resource requirements and emissions and waste, including input-output analysis for evaluation of the contribution of final demand by categories;

• Support further studies on refined sector analysis on the influence of technological and institutional change and the potentials for improvement towards waste minimization, resource efficiency and sustainable resource use.

Recommendations to the Commission:

• Support activities at Eurostat and EEA for integration of sector accounts of material flows, as important tools for the integration of environmental concerns into sectoral policies, with a focus on economy-wide waste minimization, increase of resource efficiency and sustainable use of natural resources; this could be done including input-output modelling based on accounts developed in this study;

• Consider results of material flow analysis in relevant environmental policies, especially with regard to the thematic strategies on sustainable resource management, prevention and recycling of waste and IPP.

Cross-country analysis of MFA

Cross-country comparison shows that most economies studied, including the EU, its Member States and its Accession and Candidate Countries have achieved relative decoupling of material resource use from economic development. Further progress towards sustainable development will depend on the extent to which absolute reduction of primary materials use can be achieved. A problem which deserves special attention is that resources of the EU and ACC are increasingly sourced from foreign countries, which leads to a shift of the environmental problems associated with extraction, harvest and refining. Furthermore, the relatively low levels of resource productivities and their trends in ACC make clear that enormous efforts will be required only to reach the current level of the EU, which is still far below the material productivities of Japan.

Material demand and consumption of the EU, and even more that of AC, is still mainly based on non-renewable resources, indicating that resource requirements continuously contribute to an irreversible change of the global environment. Nevertheless, also resource use in the form of renewable materials (biomass) should be further analyzed critically with regard to mode of production and related environmental pressure associated with e.g. minerals fertilizer and
pesticides use in agriculture, unsustainable forestry management, and unsustainable fishing practices.

More or less all material flow accounts currently available require further improvement for better harmonization and comparability across economies. In particular, accounts for direct material inputs (DMI) need improvement of the accounting for bulk minerals for constructions and for grazing of livestock. The same applies for accounts of domestic material consumption (DMC) which is largely depending on DMI. The account for total material requirement (TMR) includes DMI but is mainly influenced by hidden flows, and thus requires further development of the database for hidden or indirect flows coefficients.

Comparative analysis of the results for DMI, DMC and TMR clearly shows that these indicators are supplementary in providing important information on material resource use each in its own right. They should therefore not be judged in order to derive one exclusive indicator for resource use, but rather be applied in a comparative manner as a set of indicators for the headline issue of resource use. Furthermore, emphasis should be put on the further elaboration of accounts for Total Material Consumption (TMC) which is actually the indicator providing the most comprehensive picture on global material resource consumption of an economy. The vision for future headline indicators could be to establish TMR for indication of the global material resource basis of an economy, and TMC as the equivalent for the economy’s domestic consumption.

Recommendations to Eurostat:

- foster development of the accounts for DMI, DMC, TMR and TMC towards harmonization for better comparability in the EU and in AC;
- to this end, take up again activities of the task force on material flow accounting, cooperate with EEA towards a clearing house for MFA related issues, provide training courses for statistical offices especially in the AC, and support further national studies on MFA;
- as a basis for harmonization, a practical handbook on material flow accounting should be developed which further clarifies and specifies the conceptual and accounting basis of the methodological guide on MFA, including e.g. standard templates for modules of MFA and coefficients databases for technical factors and multipliers for hidden or indirect flows;
the further harmonization of MFA activities will have to be implemented on the international level. The MFA work of Eurostat has set a first basis for international standardization. Eurostat, together with the EEA, could use its potential in the starting concert with OECD and other international institutions to develop a global standard in accordance with what has already been reached at the European level.

improve the analysis of the differences of resource use and efficiency in the member states and ACC in order to quantify the influence of driving forces on the constituents of material flows, considering regional characteristics, public and private investments, in order to reveal potentials for waste minimization and improved resource use through differentiated international comparison.

Recommendations to the Commission:

- consider the further integration of material resource use aspects in the thematic strategy on sustainable natural resource use, especially with regard to the global dimension of resource requirements and resource consumption of the EU and AC;

- base strategies on a set of material flow indicators including global aspects rather than on a single indicator only;

- make use of the material flow accounts for sectoral policies development as outlined before;

- pay special attention to material resource use and economic development in the Accession and Candidate Countries; an increase of resource efficiency in the ACC is a prerequisite not only for improved coherence within the extended EU, but also for international competitiveness in terms of integrated economic and environmental performance; for that purpose, strategies should be developed to use the potentials for improvements of resource productivity within each country and each relevant sector, in order to increase welfare, reduce resource use and minimize problem shifting to other regions.

Globalization and trade

The database developed in this study provides a powerful tool for analysis of the development of material resource requirements and land use in comparison with economic performance due to international trade of the EU, with regard to commodities and materials as well as with regard to the regions concerned. In particular, it allows monitoring of shifts of resource requirements and related environmental pressures to foreign countries.
The EU has increasingly shifted its material resource requirement and related environmental pressures to foreign countries. Developing countries (DC) are still major providers of raw materials to the EU and carry an overproportional and increasing burden of hidden flows. Newly industrializing countries (NIC) in and outside Europe increasingly export semi-manufactured and finished products to the EU. New trends indicate shifts towards EU imports of higher manufacturing level from DC and NIC, but these are still minor in quantities. Pollution intensive imports (excl. fossil fuels) stem mainly and increasingly from DC and NIC in Europe causing environmental pressure through emissions and wastes especially in DC and European NIC.

The increasing material requirement of the EU is not mainly for final domestic consumption rather than for the production of exports, and thus also related to resource requirements of the receiving economies. This underlines the importance to consider total resource requirements of imports as well as exports. For that purpose, a physical trade balance (PTB) can be provided which considers the hidden flows of imports and exports. As a result, foreign trade of the EU is characterized by a high and increasing imbalance in physical terms, and the PTB considering the TMR of imports and exports indicates growing disparities of resource use and related environmental pressure between economic regions. Disparities of the EU physical foreign trade concerns mainly DC and SIC, but the highest increase is related to trade with European NIC. These additional net shifts of environmental pressure to other countries, put the reduction of environmental pressure achieved within the EU during recent years into a different perspective.

The conclusion derived from a more comprehensive perspective of economy-wide MFA including trade flow analysis is, that domestic final demand is not the ultimate driver of growing physical trade flows and associated resource requirements; rather, it is the final demand in other economies and the intermediate demand of the export manufacturing industry in the EU. So, export is the important driving force for the trade related physical imbalance of material requirement of the EU. Development of final demand in the DC/NIC, also with respect to dematerialization, will determine the global resource consumption on the medium and long term.

The EU requires about 3 times more agricultural land in foreign countries through imports than it provides to the rest of the world by exports. This concerns mainly developing countries outside Europe and in particular severely indebted countries and Latin America, but increasingly also newly industrializing countries in Eastern Europe. The effects of the forthcoming extension of the EU on the regional distribution of its global land use
requirement for agricultural goods are still largely unknown and should be subject to further monitoring and analysis.

On the global scale, the EU requires an amount of agricultural land for the per capita consumption of agricultural goods similar to the world population on average. However, predictions of the future requirement and availability of agricultural land for the world population point towards the necessity to reduce the global agricultural land use of the EU in the medium to long term. Again, this has to be further analyzed under the wider perspective of future enlargement of the EU and its prospective effect on agricultural land use for domestic consumption. Land use in a broader sense should be included in a strategy for sustainable management of natural resources, in order to evaluate relations between material resource flows and land use, and potential trade-offs between different types of land use, e.g. considering the loss of bioproductive and natural areas through the increase of land due to the expansion of the technosphere. A trade-off of increasing importance which deserves special attention relates to the competition of biofuels and biomass grown for materials use in the non-food area.

A reduction of the global Total Material Consumption (TMC) in the course of economic growth of the EU will require an increase of resource productivity of industries delivering to public and private final demand in the EU. A reduction of the imbalance of foreign physical trade will require an increase of resource productivity of export industries. Both of these desired developments should lead to an absolute reduction of TMR, especially its non-renewable share.

Transnational companies (TNC) should be taken into account in addition to the analysis based on national economies, as TNC largely determine international trade flows through their strategic decisions (in 1995, the share of foreign companies of TNC in global exports in monetary terms had reached 45% - Le Monde diplomatique 2003). They probably determine a significant share of global GDP as well as of the global resource requirements, although reliable data on the physical implications are largely lacking. The Commission may consider to take a leading role in the development of a global strategy for sustainable natural resource management, including stakeholders with high environmental and economic relevance on the global scale.

In order to develop an effective strategy on sustainable resource use, the position of the EU in the increasingly globalized economy has to be considered. As basis for policy planning and assessment the measurement of resource use and productivity should consider the domestic as
well as international dimension, i.e. the TMR of imports and exports, and land use on the global scale. Official reporting systems are challenged in this respect, especially statistical offices and environment agencies. With regard to indirect climate gas emissions, some institutions have already accounted also for transnational emissions related to domestic activities. Analoguously, the indirect resource requirements of domestic activities will have to be considered.

Recommendations to Eurostat:

- Integrate the data system developed in this study into regular activities, to monitor trends of resource use and land use through international trade in relation to driving domestic activities and economic value added;

- Encourage and support national statistical offices to integrate the methodology as well, in order to allow monitoring the effect of market integration and comparative analysis on the level of the EU and Member States as well as Accession countries,

- Analyse the possibilities to reduce the imbalance of foreign trade, and quantify the technological and institutional potentials to increase resource productivity of industrial sectors while minimizing the shift of environmental pressure.

The recommendations to the Commission:

- Pay special attention to the export driven increase of material resource requirements of the EU when developing the sustainable natural resource use strategy,

- Within this context, consider land use requirements and related environmental pressures on the global scale in a comparative manner with material resource flows and the relation to economic development,

- Consider disparities of physical trade not only in terms of value added and environmental pressure, but also in the context of social effects and resource conflicts especially in developing countries which strive for the establishment of local and regional markets, but also with regard to the continuous and globally growing use of non-renewable resources which interferes with international security. Increases of resource efficiency and sustainable patterns of resource use may also be regarded as a means for reducing regional and global resource conflicts.
Acknowledgement

We are grateful to the European Commission for financial support of this study.

We thank Stefan Bringezu for helpful comments on the draft version of this report. Thanks are also due to Sabine Schneider for support on data acquisition and analysis. We further thank José Acosta Fernández who contributed to the input-output calculations presented in this study in chapter 1.
References and further reading


Börsenlexikon (stock exchange encyclopaedia): http://www.boersenlexikon.de/


German centre for political education (Bundeszentrale für politische Bildung): http://www.bpb.de/


OECD: http://www.oecd.org/infobycountry/0,2646,en_2649_201185_1_1_1_1_1,00.html


Project SEATRANS: www.seatrans.net


Scasny, M., H. Kovanda (2001), Material flow analysis in the Czech Republic: accounts, balance and derived indicators of material flows for the Czech Republic in 1990-1999. Project of the Ministry of the Environment of the Czech Republic R&D/310/2/00 "Methodology of state assessment and prediction of the environment by the material an energy flow (direct as well hidden) balances". Charles University Environment Center, Prague. (in Czech)


UN human development reports: http://hdr.undp.org/reports/default.cfm

UN COMTRADE: http://unstats.un.org/unsd/comtrade/


Annex
Table A 1: Allocation of domestic material input flows to economic sectors (NACE 4-digits).

<table>
<thead>
<tr>
<th>NACE</th>
<th>Material flows</th>
<th>4-digits level</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Agriculture, hunting and related service activities</td>
<td></td>
</tr>
<tr>
<td>01.1</td>
<td>Growing of crops; market gardening; horticulture</td>
<td>Domestic harvest of cereals and other crops n.e.c., related unused biomass and erosion</td>
</tr>
<tr>
<td>01.11</td>
<td>Growing of cereals and other crops n.e.c.</td>
<td>Domestic harvest of cereals and other crops n.e.c., related unused biomass and erosion</td>
</tr>
<tr>
<td>01.12</td>
<td>Growing of vegetables, horticultural specialities and nursery products</td>
<td>Domestic harvest of vegetables and horticultural specialities, related unused biomass and erosion</td>
</tr>
<tr>
<td>01.13</td>
<td>Growing of fruit, nuts, beverage and spice crops</td>
<td>Domestic harvest of fruit, nuts, beverage and spice crops, related unused biomass and erosion</td>
</tr>
<tr>
<td>01.3</td>
<td>Growing of crops combined with farming of animals (mixed farming)</td>
<td></td>
</tr>
<tr>
<td>01.30</td>
<td>Growing of crops combined with farming of animals (mixed farming)</td>
<td>Domestic harvest of fodder crops n.e.c. incl. Grazing of domestic livestock on permanent pastures, related unused biomass and erosion</td>
</tr>
<tr>
<td>01.5</td>
<td>Hunting, trapping and game propagation, including related service activities</td>
<td></td>
</tr>
<tr>
<td>01.50</td>
<td>Hunting, trapping and game propagation, including related service activities</td>
<td>Domestic hunted biomass</td>
</tr>
<tr>
<td>02</td>
<td>Forestry, logging and related service activities</td>
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Domestic material inputs: used and unused
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<tr>
<th>Code</th>
<th>Industry Description</th>
<th>Sub-Code</th>
<th>Activity Description</th>
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<tr>
<td>02.0</td>
<td>Forestry, logging and related service activities</td>
<td>02.01</td>
<td>Forestry and logging</td>
</tr>
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<td>Forestry and logging</td>
<td>02.01</td>
<td>Domestic logging and production of cork, related unused biomass and erosion</td>
</tr>
<tr>
<td>05</td>
<td>Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing</td>
<td>05.0</td>
<td>Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing</td>
</tr>
<tr>
<td>05.0</td>
<td>Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing</td>
<td>05.01</td>
<td>Fishing</td>
</tr>
<tr>
<td>05.01</td>
<td>Fishing</td>
<td>05.01</td>
<td>Domestic fish catch, related unused biomass</td>
</tr>
<tr>
<td>10</td>
<td>Mining of coal and lignite; extraction of peat</td>
<td>10.1</td>
<td>Mining and agglomeration of hard coal</td>
</tr>
<tr>
<td>10.1</td>
<td>Mining and agglomeration of hard coal</td>
<td>10.10</td>
<td>Mining and agglomeration of hard coal</td>
</tr>
<tr>
<td>10.2</td>
<td>Mining and agglomeration of lignite</td>
<td>10.20</td>
<td>Mining and agglomeration of lignite</td>
</tr>
<tr>
<td>10.3</td>
<td>Extraction and agglomeration of peat</td>
<td>10.30</td>
<td>Extraction and agglomeration of peat</td>
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<tr>
<td>11</td>
<td>Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying</td>
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<td>Extraction of crude petroleum and natural gas</td>
</tr>
<tr>
<td>11.1</td>
<td>Extraction of crude petroleum and natural gas</td>
<td>11.1</td>
<td>Domestic mining of hard coal, related unused extraction</td>
</tr>
<tr>
<td>11.2</td>
<td>Extraction of crude petroleum and natural gas</td>
<td>11.20</td>
<td>Domestic mining of lignite, related unused extraction</td>
</tr>
<tr>
<td>11.3</td>
<td>Extraction of crude petroleum and natural gas</td>
<td>11.30</td>
<td>Domestic extraction of peat (for agriculture and fuel), related unused extraction</td>
</tr>
<tr>
<td>11</td>
<td>Extraction of crude petroleum and natural gas</td>
<td>Domestic extraction of crude oil and natural gas, related unused extraction</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Mining of uranium and thorium ores</td>
<td>Domestic mining of uranium and thorium ores, related unused extraction</td>
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</tr>
<tr>
<td>12.0</td>
<td>Mining of uranium and thorium ores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.00</td>
<td>Mining of uranium and thorium ores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Mining of metal ores</td>
<td>Domestic mining of iron ores, related unused extraction</td>
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<tr>
<td>13.1</td>
<td>Mining of iron ores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.10</td>
<td>Mining of iron ores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.2</td>
<td>Mining of non-ferrous metal ores, except uranium and thorium ores</td>
<td>Domestic mining of non-ferrous metal ores (bauxite, copper, etc.), related unused extraction</td>
<td></td>
</tr>
<tr>
<td>13.20</td>
<td>Mining of non-ferrous metal ores, except uranium and thorium ores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Other mining and quarrying</td>
<td>Domestic quarrying of stone for construction (dolomite, sandstone, etc.), related unused extraction</td>
<td></td>
</tr>
<tr>
<td>14.1</td>
<td>Quarrying of stone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.11</td>
<td>Quarrying of stone for construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.12</td>
<td>Quarrying of limestone, gypsum and chalk</td>
<td>Domestic quarrying of limestone, gypsum and chalk; related unused extraction</td>
<td></td>
</tr>
<tr>
<td>14.13</td>
<td>Quarrying of slate</td>
<td>Domestic quarrying of slate, related unused extraction</td>
<td></td>
</tr>
<tr>
<td>14.2</td>
<td>Quarrying of sand and clay</td>
<td>Domestic quarrying of sand and gravel, related unused extraction</td>
<td></td>
</tr>
<tr>
<td>14.21</td>
<td>Operation of gravel and sand pits</td>
<td>Domestic mining of clays and kaolin, related unused extraction</td>
<td></td>
</tr>
<tr>
<td>14.22</td>
<td>Mining of clays and kaolin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.4</td>
<td>Production of salt</td>
<td>14.30 Mining of chemical and fertilizer minerals</td>
<td>Domestic mining of chemical and fertilizer minerals (phosphate etc.), related unused extraction</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14.40</td>
<td>Production of salt</td>
<td>14.40 Production of salt</td>
<td>Domestic mining of salt (potash, rock salt etc.), related unused extraction</td>
</tr>
<tr>
<td>14.5</td>
<td>Other mining and quarrying n.e.c.</td>
<td>14.50 Other mining and quarrying n.e.c.</td>
<td>Domestic mining and quarrying of other industrial minerals n.e.c., related unused extraction</td>
</tr>
<tr>
<td>45</td>
<td>Construction</td>
<td></td>
<td>Domestic excavation of earth for constructions, and dredging of sediments</td>
</tr>
</tbody>
</table>
### Table A 2: Allocation of Comext foreign trade categories (CN) to economic sectors (NACE 2-digits).

<table>
<thead>
<tr>
<th>CN</th>
<th>NACE 2-digits</th>
<th>Agricultural raw materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>06</td>
<td>01</td>
<td>Alive plants</td>
</tr>
<tr>
<td>07</td>
<td>01</td>
<td>Vegetables, other</td>
</tr>
<tr>
<td>0701</td>
<td>01</td>
<td>Potatoes</td>
</tr>
<tr>
<td>0706</td>
<td>01</td>
<td>Roots+Tubers, nes</td>
</tr>
<tr>
<td>0708</td>
<td>01</td>
<td>Pulses, total</td>
</tr>
<tr>
<td>071410</td>
<td>01</td>
<td>Cassava</td>
</tr>
<tr>
<td>0801-10,-11,-19</td>
<td>01</td>
<td>Coconuts</td>
</tr>
<tr>
<td>0802-21,-22</td>
<td>01</td>
<td>Hazelnuts</td>
</tr>
<tr>
<td>0802-31,-32</td>
<td>01</td>
<td>Walnuts</td>
</tr>
<tr>
<td>0803</td>
<td>01</td>
<td>Bananas</td>
</tr>
<tr>
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**Forestry raw materials**

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**Animals raw and products**

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<td>Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials</td>
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**Agriculture animal products**

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<td>5102</td>
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**Forestry semi-manufactured products**

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<td>49</td>
<td>Paper ware</td>
<td>22</td>
<td>Publishing, printing and reproduction of recorded media</td>
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*Biotic products*
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<td>0505</td>
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<td>Bones and horn-cones etc.</td>
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<td>Turtoise-shell etc.</td>
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<td>Lard stearin etc.</td>
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<td>Fats and oils of fish etc.</td>
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<td>Other animals fats and oils etc.</td>
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<td>2104</td>
<td>Soups and broths</td>
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<tr>
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<td>4303</td>
<td>Clothing, other ware of furskins</td>
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</tbody>
</table>

**Fossils raw materials**

| CN  | 2701 | Hard coal | 10 | Mining of coal and lignite; extraction of peat |
| CN  | 2702 | Brown coal | 10 | Mining of coal and lignite; extraction of peat |
| CN  | 2703 | Peat | 10 | Mining of coal and lignite; extraction of peat |
| CN  | 2709 | Crude oil | 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying |
| CN  | 2711 | Natural gas | 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying |
| CN  | 2714 | Bituminous crude materials | 11 | Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying |

**Metals raw materials**

<p>| CN  | 2601 | Iron ores | 13 | Mining of metal ores |
| CN  | 2602 | Manganese ores | 13 | Mining of metal ores |
| CN  | 2603 | Copper ores | 13 | Mining of metal ores |
| CN  | 2604 | Nickel ores | 13 | Mining of metal ores |
| CN  | 2605 | Cobalt ores | 13 | Mining of metal ores |
| CN  | 2606 | Aluminum ores | 13 | Mining of metal ores |
| CN  | 2607 | Lead ores | 13 | Mining of metal ores |
| CN  | 2608 | Zinc ores | 13 | Mining of metal ores |</p>
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<td>2610</td>
<td>Chromium ores</td>
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<td>2611</td>
<td>Tungsten ores</td>
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<td>Uranium/Thorium ores</td>
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<td>Niob-/Tantalum ores</td>
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<td>Vanadium ores</td>
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### Minerals raw materials

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**Fossils semi-manufactured products**

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**Metals semi-manufactured products**

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<td>Cermets and goods thereof, also waste/scrap</td>
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**Minerals semi-manufactured products**

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<td>Potassium fertilizers</td>
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**Metals finished products**

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**Minerals finished products**

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**Abiotic products**

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<td>Manufacture of wearing apparel; dressing and dyeing of fur</td>
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**Other products**

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<td>Nitrogen fertilizers</td>
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<td>NPK fertilizers and other fertilizers</td>
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<td>31 Rest</td>
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<td>Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear</td>
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676 Myanmar
684 Laos
690 Vietnam
696 Cambodia
700 Indonesia
716 Mongolia
724 North Korea
806 Solomon Is.
807 Tuvalu
824 Marshall Is.
Table A 5: Aggregation of countries: developing countries outside Europe (DC), least developed countries (LDC), newly industrializing countries (NIC) in Europe and outside Europe: based on Eurostat Comext 2001 (LDC, NIC).

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<th>Least developed countries (LDC)</th>
<th>Newly industrializing countries (NIC) outside Europe</th>
<th>Newly industrializing countries (NIC) Europe</th>
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North Korea
North Yemen
Northern Marianas
Oman
Pakistan
Palau Islands
Palestinian Admin. Areas
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Puerto Rico
Qatar
Reunion
Rwanda
Saint Helena
Saint Kitts-Nevis
Saint Lucia
Saint Vincent and Grenadines
Samoa
Sao Tome and Principe
Saudi Arabia
Senegal
Seychelles
Sierra Leone
Singapore
Solomon Islands
Somalia
South Africa
South Korea
South Yemen
Sri Lanka
Sudan
Suriname
Swaziland
Syria
Taiwan
Tanzania
Thailand
Togo
Tokelau
Tonga
Trinidad & Tobago
Tunisia
Turks & Caicos Islands
Tuvalu
U.A.Emirates
Uganda
Uruguay
Vanuatu
Venezuela
Viet Nam
Virgin Islands (UK)
Wallis & Futuna
Yemen
Zaire
Zambia
Zimbabwe
Table A 6: Aggregation of countries: Geographical regions.

WTO
This Note details the definitions, methods and sources of the statistics used in International Trade Statistics 2001.

I. Composition of country groups

1. Regions

North America:
1. Canada
2. United States of America
3. territories in North America n.e.s.

Latin America:
4. Antigua and Barbuda
5. Argentina
6. Bahamas
7. Barbados
8. Belize
9. Bolivia
10. Brazil
11. Chile
12. Colombia
13. Costa Rica
14. Cuba
15. Dominica
16. Dominican Republic
17. Ecuador
18. El Salvador
19. Grenada
20. Guatemala
21. Guyana
22. Haiti
23. Honduras
24. Jamaica
25. Mexico
26. Netherlands Antilles
27. Nicaragua
28. Panama
29. Paraguay
30. Peru
31. Saint Kitts and Nevis
32. Kitts and Nevis
33. Saint Lucia
34. Saint Vincent and the Grenadines
35. Suriname
36. Trinidad and Tobago
37. Uruguay
38. Venezuela
39. and other countries and territories in Latin America n.e.s.

Western Europe:
40. Austria
41. Belgium
42. Denmark
43. Finland
44. France
45 Germany
46 Greece
47 Iceland
48 Ireland
49 Italy
50 Liechtenstein
51 Luxembourg
52 Malta
53 Netherlands
54 Norway
55 Portugal
56 Spain
57 Sweden
58 Switzerland
59 Turkey
60 United Kingdom
61 Bosnia and Herzegovina
62 Croatia
63 former Yugoslav Republic of Macedonia
64 Slovenia
65 Yugoslavia (the last five countries mentioned comprise the former Yugoslavia)
66 and territories in Western Europe n.e.s.
   Central and Eastern Europe:
67 Albania
68 Bulgaria
69 Czech Republic
70 Hungary
71 Poland
72 Romania
73 Slovak Republic
   the Baltic States:
74 Estonia
75 Latvia
76 Lithuania
   and the Commonwealth of Independent States (transition economies):
77 Armenia
78 Azerbaijan
79 Belarus
80 Georgia
81 Kazakhstan
82 The Kyrgyz Republic
83 Republic of Moldova
84 Russian Federation
85 Tajikistan
86 Turkmenistan
87 Ukraine
88 Uzbekistan
   Africa, of which North Africa:
89 Algeria
90 Egypt
91 Libyan Arab Jamahiriya
92 Morocco
93 Tunisia
   and Sub-Saharan Africa comprising:
   Western Africa:
94 Benin
95 Burkina Faso
96 Cape Verde
97 Côte d’Ivoire
98 Gambia
99 Ghana
100 Guinea
101 Guinea-Bissau
102 Liberia
103 Mali
104 Mauritania
105 Niger
106 Nigeria
107 Senegal
108 Sierra Leone
109 Togo

Central Africa:
110 Burundi
111 Cameroon
112 Central African Republic
113 Chad
114 Congo
115 Democratic Republic of the Congo
116 Equatorial Guinea
117 Gabon
118 Rwanda
119 Sao Tome and Principe

Eastern Africa:
120 Comoros
121 Djibouti
122 Eritrea
123 Ethiopia
124 Kenya
125 Madagascar
126 Mauritius
127 Seychelles
128 Somalia
129 Sudan
130 United Republic of Tanzania
131 Uganda

Southern Africa:
132 Angola
133 Botswana
134 Lesotho
135 Malawi
136 Mozambique
137 Namibia
138 South Africa
139 Swaziland
140 Zambia
141 Zimbabwe

and territories in Africa n.e.s.

The Middle East:
143 Bahrain
144 Cyprus
145 Iraq
146 Islamic Republic of Iran
Israel
Jordan
Kuwait
Lebanon
Oman
Qatar
Saudi Arabia
Syrian Arab Republic
United Arab Emirates
Yemen
and other countries and territories in the Middle East n.e.s.

Asia, of which West Asia:

Afghanistan
Bangladesh
Bhutan
India
Maldives
Nepal
Pakistan
Sri Lanka

East Asia:

Brunei Darussalam
Cambodia
China
Hong Kong Special Administrative Region of China (Hong Kong, China)
Indonesia
Japan
Lao People’s Democratic Republic
Macau, China
Malaysia
Mongolia
Myanmar
Philippines
Republic of Korea
Separate Customs Territory of Taiwan
Penghu, Kinmen and Matsu (Taipei, Chinese)
Singapore
Thailand
Viet Nam
other countries and territories in Asia n.e.s.

Oceania:

Australia
Fiji
Kiribati
New Zealand
Papua New Guinea
Samoa
Solomon Islands
Tonga
Tuvalu
Vanuatu
other countries and territories in the Pacific n.e.s.
Table A 7: Aggregation of countries: Economic regions.

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ST VINCENT and THE GRENADINES
SUDAN
SURINAME
SWAZILAND
TANZANIA
TCHAD
TOGO
TONGA
TRINIDAD and TOBAGO
TUVALU
UGANDA
VANUATU
WESTERN SAMOA
ZAMBIA
ZIMBABWE