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DMI and DMC for Sweden1987-1997

Prepared for DG Environment and Eurostat by:
A. Isacsson/K. Jonsson/I. Linder/V. Palm/A. Wadeskog
Statistics Sweden

eurostat

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Direct Material Inputs (DMI) and Domestic Material Consumption (DMC) for Sweden 1987 - 1997

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Preface

As part of work to develop environmental accounting linked to national accounts and input-output tables, Eurostat is currently looking at **economy-wide material flow accounts and aggregate material balances**. These accounts provide aggregate descriptions of the material flows through economies and allow for the derivation of aggregate indicators of material use and material efficiency when compared to e.g. Gross Domestic Product (GDP). A preliminary basic layout of economy-wide material balances showing the aggregate indicators that can be derived from such accounts is presented overleaf.

This Working Paper, presenting the results of work by Statistics Sweden on Direct Material Inputs (DMI), is an essential contribution to the development of economy-wide material flow accounts and balances. Eurostat distributes this report hoping that those wishing to implement economy-wide material flows can benefit from the Swedish experience.

Brian Newson
Head of Unit B1
National accounts methodology,
statistics of own resources

EUROSTAT DRAFT SCHEME FOR ECONOMY-WIDE MATERIAL BALANCES

Economy-wide material balance with derived indicators

(excludes air & water flows)

INPUTS (origin)	**OUTPUTS (destination)**
Domestic extraction	**Domestic processed output to nature**
Fossil fuels (coal, oil…)	***Emissions and wastes***
Minerals (ores, sand…)	Emissions to air
Biomass (timber, cereals…)	Waste landfilled
	Emissions to water
Imports	***Dissipative use of products***
DMI - direct material inputs	(Fertiliser, manure, compost, seeds..)
	DPO - domestic processed output to nature
Unused domestic extraction	
Mining/quarrying overburden	**Disposal of unused domestic extraction**
Soil excavation	Mining/quarrying overburden
Erosion	Soil excavation
TMI – total material input	Erosion
	TDO - total domestic output to nature
Hidden flows[1]) imported	
TMR - total material requirements	**Exports**
	TMO – ***total material output***
	Net Additions to Stock (NAS)
Note: terminology not yet fully standardised	Infrastructures and buildings
	Other (machinery, durable goods, etc.)
	Hidden flows exported

Source: Eurostat

This account allows derivation of key material use indicators for inputs (DMI, TMI and TMR), outputs (DPO, TDO and TMO) as well as calculation of aggregate material consumption indicators (NAS, DMC and TMC). DMC and TMC are calculated as follows:

- *DMC (domestic material consumption)* = Domestic extraction + Imports – Exports = DMI - Exports
- *TMC (total material consumption)* = Domestic extraction (used and unused) + Imports + hidden flows imported - exports - hidden flows exported

These indicators are linked by accounting identities. For example, TMI (total material input) = TMO + NAS; or NAS = DMC – DPO. It is important to have the indicators in a long time series in order to identify longer-term trends and isolate changes that are due to economic cycles.

[1] Hidden flows (or ecological rucksacks) are a measure of material flows that are 'hidden' behind the goods imported or exported. In the exporting country, hidden flows are the total material inputs (i.e. TMI) needed to produce the goods exported. In the importing country these hidden flows are a measure (as part of TMR) of the material flows that its imports induce in the exporting country. Hidden flows do not enter the importing (or leave the exporting) country. Rather, they are a way of converting the imported inputs of a country into a common basis of primary resource extraction, thus indicating the impact on other countries. In some studies the unused domestic extraction (e.g. mining overburden) is called 'domestic hidden flows' to underline that such flows are often without monetary value and thus not recorded in economic accounts. Standard methodologies for estimating hidden flows (in particular hidden flows exported) are only just developing.

Foreword

Statistics Sweden has developed physical environmental accounts since 1993. This report is a result of developmental work on incorporating descriptions of material flows into the Swedish environmental accounts. In this report, the size of the Swedish so-called direct material input (DMI) is estimated from 1987 to 1997. The study includes time series of main primary categories of direct material inputs in the society, such as raw materials from agriculture, forestry and mining, as well as imports of goods and materials. The DMI is also further analysed, so that exports are separated from the national consumption itself. An attempt is also made to couple this information to environmental pressure as recorded in the environmental accounting system, through a monetary input-output analysis.

The report is prepared on commission from Eurostat, which supports and co-ordinates development of environmental accounts in the EU Member States. The European Commission (DG Environment) has contributed financially to the project. Several people have been engaged in different areas and in preparing this report. They are Annica Isacsson (emissions and waste), Kristina Jonsson (non-renewable materials and analysis), Irene Linder (renewable materials), Viveka Palm (project leader and analysis), Anders Wadeskog (input-output analysis).

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APPENDIX 3 Direct Material Input per capita and Domestic Material Consumption per capita, totals and divided into Fossil fuels, Other non-renewables and Renewables.

APPENDIX 4 Direct Material Input and Domestic Material Consumption, totals and divided into Fossil fuels, Ores, Industrial minerals, Construction minerals, Raw material for food production and Forestry.

Summary

Many environmental problems are connected to production and use of materials and energy. It would therefore be desirable to have an information system for material and energy flows, preferably connected to economic data. The environmental accounts provide such a framework, but comprehensive statistics on material flows have not been available until now. Statistics Sweden is now in the process of developing material flow statistics for Sweden. One part of this work focuses on an aggregate description of the total material throughput for the society. This knowledge can be used to work towards eco-efficiency by improving the resource productivity. The results contribute to the work with environmental accounts and provide a link between society's use of materials and natural resource accounting. By establishing material flow statistics, policies on materials and eco-efficiency will have a firmer point of reference.

In this report, the size of the Swedish use of natural resources is estimated from 1987 to 1997. An attempt is made to couple this information to environmental pressure as recorded in the environmental accounting system, through a monetary input-output analysis. The study includes main primary categories of direct material inputs (DMI) in the society such as inputs from foreign trade, agriculture, forestry, mining and fuels, and outputs such as exports, waste, and air emissions. The project does not include the detailed supply-use structure in physical terms (as e.g. presented in physical input-output tables – PIOT), nor the hidden flows and the rucksacks presented in studies of total material requirement (TMR). This study is an attempt to calculate the total national yearly input of raw materials with an economic value. The system boundary is set to describe the primary inputs from the environment (or the rest of the world) as they enter the Swedish economy. Focusing on the materials that enter the technosphere eliminates double counting of successive stages of refined products etc. In order to avoid double counting, those materials *that are taken from biosphere to technosphere during the year* are singled out.

DMI per capita amounts to around 28 tonnes per capita for the period 1987-1998, with highest values 1989 and 1995. The fossil fuel input varies only slightly over the period, from 3,2 tonnes/capita in 1991 to 3,6 in 1996. Renewable raw materials vary between 7,9 and 9,1 tonnes per capita. The non-renewable categories ores and minerals vary between 14,8 and 18,8 tonnes/capita.

This calculation puts Sweden above the estimates made for Germany, USA and Japan, and in the same size as the Netherlands. There are several explanations for the differences. Differences can be explained by system boundaries, by data sources and by how the exports are treated.

For the fossil fuels, Sweden and Japan have similar per capita figures of about 3 tonnes/capita.

For the construction minerals Sweden has a high figure. This can be explained by what statistics have been available, as the economic statistics may have different system boundaries than what is wished for. For example, in this study raw material statistics was often taken from sources other than the industrial statistics.

For the renewable materials, Sweden's per capita input appears to be 5 tonnes higher than in other countries, which may be explained by the dominating forest industry. Also for food production the figures are higher than the USA, Germany and Japan. This may be due to the choice of statistical sources.

The system boundary chosen for the ores has a major impact on the results. The international comparison made it clear that earlier studies have had a boundary different to the one chosen in this study. The *concentrates* of metals have been considered direct flows, while we have considered the *ores* as direct flows. We present re-calculated figures that can be compared to the

international figures, but the main text of the report is based on the definition of ores as direct flows. This can be recalculated in future work. Also recalculated, the ores will be more important for Sweden than for the other countries in the comparison, since mining is a major industry in Sweden.

The fact that Sweden is a small country with a relatively large export of raw materials such as forestry and ores is evident in the results. If we separate the export from the domestic material consumption (DMC) the per capita figures decrease by about 5 tonnes per capita. This separation is important in order to distinguish life style changes from exports of raw materials.

Different raw materials have been allocated to branches of industry by means of input-output analysis. Unfortunately, because of the aggregation of the monetary input-output table, ores and industrial minerals could not be separated. This problem that the monetary tables could not single out such different industries could not be solved within this project.

Similar input-output analyses were performed for air emissions and hazardous waste. The expected connections between carbon dioxide emissions from energy intensive mining and large material flows are seen.

Further studies are obviously needed in order to provide us with the tools for allocating physical flows over industries or commodities, with better precision. One of these tools will most likely be disaggregated monetary input/output tables.

1.1 Introduction

Many environmental problems are connected to production and use of materials and energy. It would therefore be desirable to have an information system that gives consistent and complete information on material and energy flows. Such a system would even be more useful if it could be connected to economic data. The environmental accounts provide such a framework, but comprehensive statistics on material flows have not been available until now. Statistics Sweden is now in the process of developing material flow statistics for Sweden. One part of this work focuses on an aggregate description of the total material throughput for the society, with a methodology similar to what has been suggested internationally (WRI, 1997). This knowledge can be used to work towards eco-efficiency by improving the resource productivity. The results contribute to the work with environmental accounts and provide a link between society's use of materials and natural resource accounting.

We are interested in describing the environmental pressures from a nation's economic activities through its producers and consumers. The producers purchase energy, materials, labour and capital to produce goods and services. This production process also produces waste, air emissions and water emissions (Figure 1).

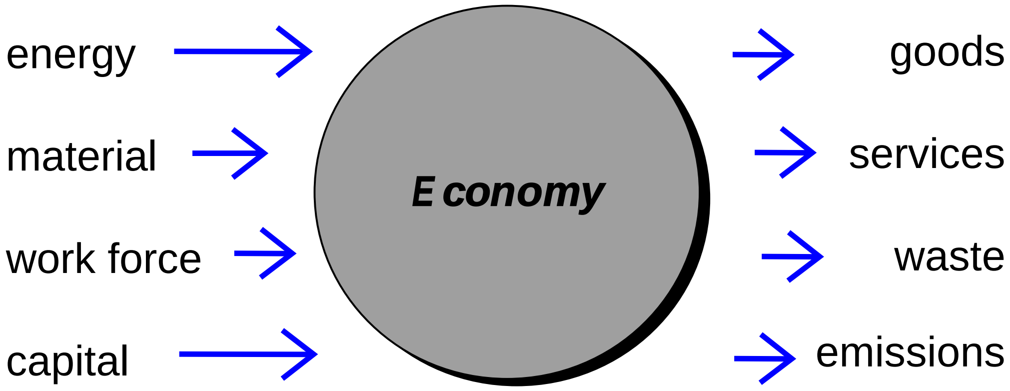

Figure 1. Input to and output from the economy

The environmental accounts aim at quantifying these resource flows and the relationships between them. From a sustainable development point of view, the economic system should produce the desired goods and services with a minimum of environmental impacts. This can only partly be achieved by reducing emissions from specific processes by end-of-pipe solutions, and reducing waste by recycling.

The size and composition of the inputs in the production process is of great importance for the resulting environmental pressure. This is particularly clear for carbon dioxide emissions from fossil fuel input, as well as for the use and spreading of chemicals. As the economy grows, so do the inputs of materials into the system. However, a counter-balancing factor is the energy and material efficiency gains that occur in the development of new products and new equipment.

If, for example, these effects balance out each other, we are facing a development with constant environmental pressures. This is not a satisfactory situation, as the recently defined Swedish environmental quality objectives will only be met if the environmental pressures are reduced.

Until now, there has been no coherent statistics on material flows to follow the development of material inputs. By establishing material flow statistics, policies on materials and eco-efficiency will have a firmer point of reference.

In this report, the size of the Swedish use of natural resources is estimated from 1987 to 1997. An attempt is made to couple this information to environmental pressure as recorded in the environmental accounting system, through a monetary input-output analysis. The study includes main primary categories of direct material inputs (DMI) in the society such as inputs from foreign trade, agriculture, forestry, mining and fuels, and outputs such as exports, waste, and air emissions. The project does not include the detailed supply-use structure in physical terms (as described e.g. in PIOTs), nor the hidden flows and the rucksacks presented in studies of total material requirement (TMR).

In the future, results from similar studies may show the increase of stocks in society. However, due to incomplete solid waste data, no such estimates are included now. The time series have their main focus on the input side, as the output statistics have not been produced with the same frequency. To make it possible to compare the use of material between different sectors of society, the input and output is divided into aggregated industries (by NACE) as far as possible.

1.2 Method

This study is an attempt to calculate the total national yearly input of raw materials with an economic value. In order to avoid double counting, those materials *that are taken from biosphere to technosphere during a year* are singled out. The method concentrates on the primary input, and avoids calculating the materials, substances and products that have already been accounted for as primary input.

This means, for example, that figures from plastic industry are not of primary interest in this work, since their raw material is already counted for as crude oil, industrial minerals or other primary goods. It also means that meat from the food industry is mainly recorded as the feed to produce poultry, etc. However, as the nation's material use is also covered by imports of raw materials as well as products, this method has its limitations. In accordance with similar studies, the import of goods is therefore recorded separately. Ideally, these goods should of course have been recalculated to their primary input. Since methods and data are lacking for that kind of recalculation, they are merely presented by their weight.

The method gives an aggregated figure of yearly raw material input. It shows the total and the share of renewable and non-renewable materials. In this form, it can be compared with figures from similar studies, and possibilities for resource efficiency can be highlighted.

As a further development, the figures have also been complemented with export figures. This is made in order to single out the input for national consumption from the input used in production for export purposes. Sweden is dependent on its export of raw materials such as ores and pulp. If consumers in Sweden would become more resource efficient, while the exports of raw materials to other countries increased, it is important that our measures on resource use can distinguish between these phenomena. Final demand is presented as national consumption and exports. National consumption is defined as domestic production plus imports minus exports.

By comparing the raw material input with data on waste and emissions, the connections between material and energy input to different kinds of output can be explored. To make it possible to compare the use of material between different sectors of society, the input is divided into aggregated industries (by NACE). This makes it possible to link to other areas of the environmental accounts, by means of input/output-analysis. In this study, the linkage between material input and emissions of sulphur dioxide, nitrogen oxides and carbon dioxide and waste, are investigated by means of input-output analysis.

Information on domestic production has been gathered from several sources, as reported in the different chapters. The industrial statistics have not been used to the extent that was expected, mainly because these statistics are designed to cover monetary flows rather than material flows. This means that a number of cut-off criteria which are of minor importance for the economic statistics, creates difficulties in estimating the completeness of the material flows.

Information on imports and exports is taken from Statistics Sweden's database for statistics on foreign trade. For enterprises that export to and import goods from countries outside the EU, the information used is taken from the export statements and import declarations submitted by the enterprises to the customs authorities in conjunction with the export/import of goods. The customs authorities provide information on volumes, weight and value.

From enterprises that have annual transfers of goods to or from other EU countries worth at least SEK 1 500 000, data on volumes, weights and values is collected on a monthly basis. The information provided by enterprises is reported with breakdowns by goods (using the same breakdown of goods as in trade with countries outside the EU) and EU country.

2 Input: Raw materials

2.1 Non-renewable materials

2.1.1 Fossil fuels

Fossil fuels are counted in this group whether they are used as energy sources or not. Empirically, we know that the latter use is negligible except for crude oil. Fossil fuels are divided into groups of solid, liquid and gaseous fuels.

Hard coal, lignite and peat for combustion are solid fossil fuels. The domestic production of hard coal is a secondary product from clay production. Only small quantities of hard coal and lignite are imported to Sweden. Hard coal is used to produce coke. Thus coke is not counted to the domestic production, only imported coke is counted. Peat for combustion is a fossil fuel, while peat for other purposes, for example horticultural peat, is an industrial mineral.

Liquid fossil fuels are crude oil and products of crude oil. Domestic production of petroleum products is not counted in this model since input for this production is the imported crude oil. These products are given in quantities of volume in the Swedish energy statistics and must be recounted with product specific densities.

Gaseous fossil fuels are natural gas and gaseous products from natural gas, crude oil or hard coal. There is no production of natural gas in Sweden, but there is domestic production of liquefied petroleum gas, gaswork gas, coke-oven gas and blast-furnace gas. Liquefied petroleum gas is prepared from crude oil or natural gas, gaswork gas is prepared from light distillates, liquefied petroleum gas or natural gas.[2] Coke-oven gas is a secondary product from the production of coke, and blast-furnace gas is a secondary product from blast-furnace processes. Raw material for this production is accordingly crude oil, natural gas and hard coal. Imports of gaseous fossil fuels should of course be added.

Data for the domestic production, imports and exports for all fossil fuels, except for peat, are gathered from Statistics Sweden’s energy statistics. In order to separate peat for combustion from peat for other purposes Statistics Sweden’s statistical report ”Peat 1997, Resources, use, environmental impact” was used. Information on imports and exports of peat is taken from Statistics Sweden’s statistics on foreign trade.

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[2] Statistics Sweden, 1987-1997. *Yearly Energy Balance Sheets*.

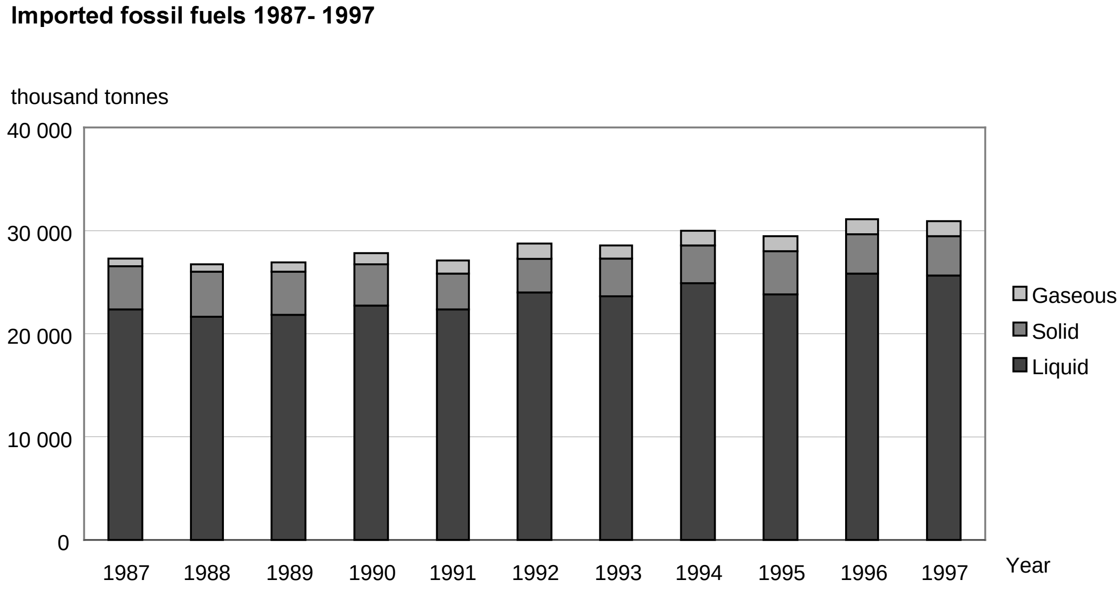

Diagram 1 Imported fossil fuels 1987-1997, divided into gaseous, solid and liquid fuels.

Diagram 1 shows the import of fossil fuels during 1987-1997 divided by solid, liquid and gaseous fossil fuels. More than 80 percent of the imported fuels is liquid fuels. The imported liquid fuels have increased from 22 million tonnes to 26 million tonnes during this time-period. The imports of solid fuels decreased during the first half of the nineties and is now lower than in the late eighties. Imports of gaseous fuels are increasing, and are now twice the sizes in the late eighties. Total imports of fossil fuels has risen from 27 million to 31 million tonnes during this time period.

2.1.2 Ores

There are two types of mines in Sweden, iron ore mines and non-ferrous ore mines. The non-ferrous ore mines produce copper, lead, zinc, gold and silver. The non-ferrous ores also contains iron pyrites which until 1992 was raw material for the domestic production of sulphuric acid.[3] Sweden has during this period been the main producer of iron ore, lead and silver in Europe, and ranked third producing country of copper, zinc and gold.[4] Table 1 below presents the metal content in the produced non-ferrous ores (concentrates) copper, lead, zinc, gold and silver and the content of sulphur in the produced iron pyrites.

[3] The Association of Swedish Chemical Industries, 1995. *Swedish chemical industry Facts and figures.*
[4] The Geological Survey of Sweden, 1987-1997. *Statistics of the Swedish mining industry.*

Year	Copper tonnes	Lead tonnes	Zinc tonnes	Gold kg	Silver kg	Sulphur tonnes
1987	86113	95141	229353	4108	254107	215678
1988	75032	91579	200393	3590	207804	286387
1989	71238	88967	173515	5120	227715	232812
1990	74283	98259	164128	6326	242685	230833
1991	81650	91127	161170	6247	239321	83373
1992	89145	105295	171539	6164	311059	18199
1993	88909	111709	168617	6548	298772	-
1994	79384	112787	159858	6364	275224	-
1995	83603	100070	167962	6528	268200	-
1996	71659	98812	160133	6145	271866	-
1997	86610	108624	155385	6777	304048	-

Table 1 Content of metal or sulphur in non-ferrous ores (concentrates)
Source: Statistics of the Swedish mining industry 1997, The Geological Survey of Sweden

In diagram 2 below domestic production of ore is shown as iron ore and non-ferrous ore. Data is collected from ”Statistics of the Swedish mining industry” published by The Geological Survey of Sweden. The domestic production of iron ore has been varying between 20 million and 25 million tonnes during the time period. The domestic production of non-ferrous ore has increased during the whole period, from barely 19 million tonnes in 1987 to almost 25 million tonnes in 1997. In the nineties the production of non-ferrous ore has exceeded the production of iron ore.

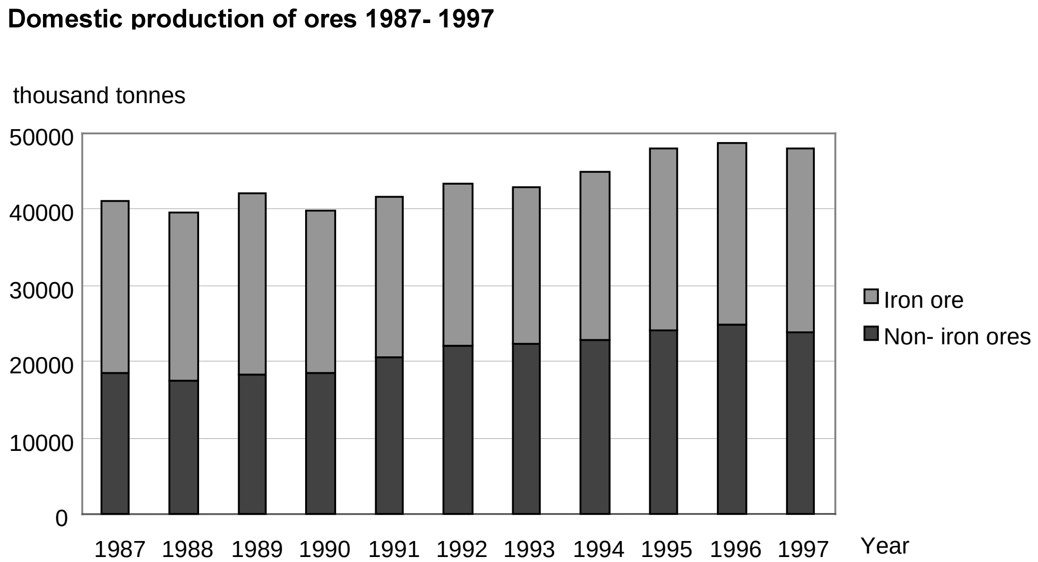

Diagram 2. Domestic production of ores 1987-1997, divided into iron ores and non-ferrous ores

Information on imports and exports is taken from Statistics Sweden's database for statistics on foreign trade. Several goods has been counted for, the entire C*hapter 26 Ores, slag and ash* and the whole S*ection XV Base metals and articles of base metal*. Some white goods have been selected from *Chapter 84 Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof*. Cars is selected from *Chapter 87 Vehicles other than railway or tramway rolling stock, and parts and accessories thereof*.

In the future, we hope to be able to express the imports and exports in terms of raw materials instead of goods. In this work, only cars has been recalculated into their raw material ore. *Ore* is what we in this study define as direct material flow. (Unfortunately, we noticed rather late in the study that the other international studies have used a more narrow definition of "ore flow with an economic value". They have calculated *concentrates* as direct material flow. In future work we may have to change our definitions and then some of the flows now counted for as direct will be moved to become hidden. The iron and steel content in cars is estimated to 70 per cent according to a life cycle analysis performed by IVL Swedish environmental research institute Ltd.[5] There are also estimates of the metal content in domestic produced iron ore performed by Geological Survey of Sweden.[6] Under the assumption that the iron content is the same in the ore that the imported cars are produced of, the ore consumption to produce the imported cars are estimated. An estimate for the exports is found by analogy with the estimate for imports.

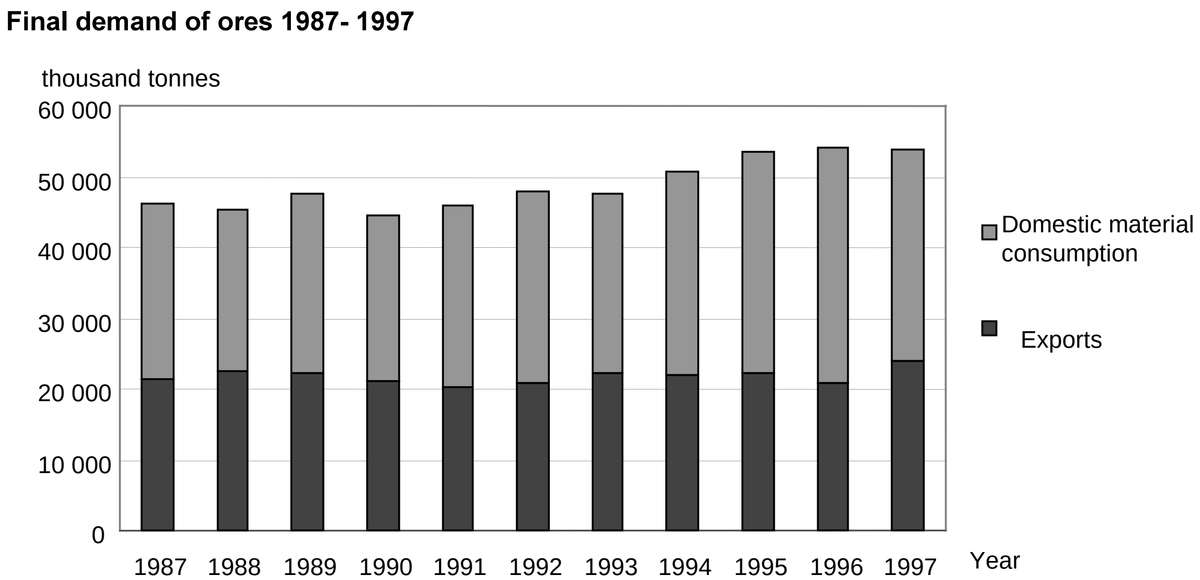

Diagram 3. Final demand of ores 1987-1997, divided into domestic material consumption and exports.

Every year between 20 million and 24 million tonnes of ore has been exported from Sweden, which corresponds to almost half of the annual supply of ore. In recent year domestic material consumption has increased (Diagram 3).

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5 IVL Swedish environmental research institute Ltd, 1997. *B-report 1251.*

6 The Geological Survey of Sweden, 1987-1997. *Statistics of the Swedish mining industry.*

2.1.3 Industrial minerals and rocks

Industrial minerals and rocks are minerals and rocks that are produced for other reasons than because of its metal content or energy content. Industrial minerals and rocks can be divided into three groups: advanced industrial minerals, natural rocks and aggregates. They can also be described as either industrial minerals or construction minerals. Industrial minerals refer to minerals and rocks extracted because of their chemical or physical properties, whereas construction minerals are used directly or indirectly for structural and civil engineering. Material flow of minerals and rocks defined as construction minerals are far greater than the flow of industrial minerals.

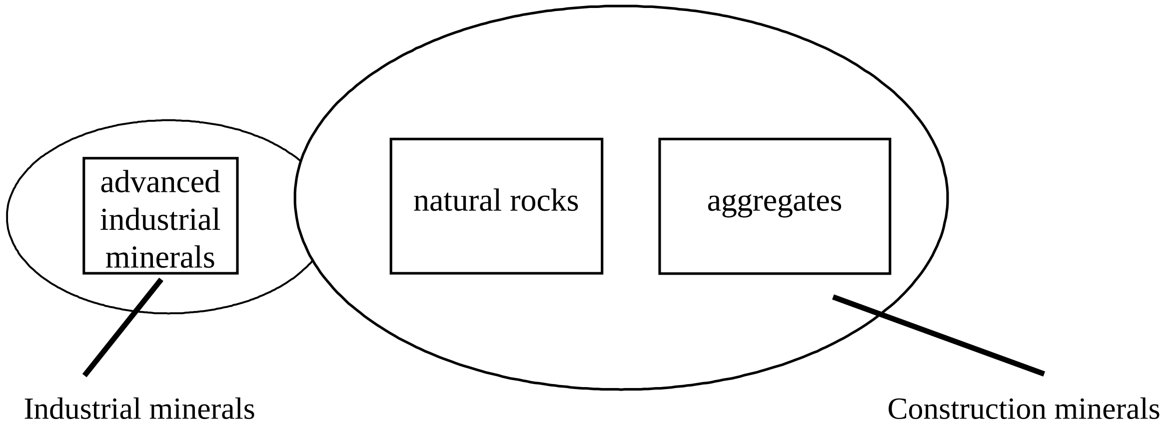

Figure 2 Industrial minerals and Construction minerals

The distinction between industrial and construction minerals is not always clear, since a mineral can fall under both definitions depending on how it is used. Limestone for example is used for several purposes. Because of its chemical properties limestone is used to raise the pH-value of acidified lakes, this makes limestone a industrial mineral. But limestone can also be used directly for construction or used for the production of cement, which makes limestone a construction mineral. Information on domestic production is taken from The Geological Survey of Sweden. From this source you can not say how the limestone and the clay is used. Limestone used for the production of cement and clay for bricks should according to the definition above be counted for as construction minerals, since it is directly or indirectly used for structural and civil engineering.

However in 1997, 4500 thousand tonnes of industrial minerals was used for the production of cement according to Geological Survey of Sweden.[7] As limestone is the principal ingredient in cement, we presume that the intended industrial mineral primary is limestone. 4500 thousand tonnes of limestone correspond to 63 per cent of the total production of limestone 1997. Limestone defined as a construction mineral for the remaining years are assumed to be 63 per cent of the total production.

Information on imports and exports is taken from Statistics Sweden’s statistics on foreign trade. Industrial minerals are goods in *Chapter 25 Salt, sulphur, earths and stone, plastering materials, lime and cement, Chapter 68 Articles of stone, plaster, cement, asbestos, mica or similar materials, Chapter 69 Ceramic products, Chapter 70 Glass and glassware* that correspond to the definition above, remaining goods in Chapter 25, 68, and 69 are construction minerals.

[7] The Geological Survey of Sweden, 1998. *Industriella mineral och bergarter- en branschutredning.*

2.1.3.1 Industrial minerals

Several industrial minerals are extracted in Sweden, foremost limestone, dolomite, quartzite, quartz sand, olivine, clays, talc, feldspar and graphite. The production of limestone, dolomite, quartzite and quartz sand dominates by tonnage (Diagram 4). In 1997, the production of those four industrial minerals represent 70 per cent of the total production of almost 6 million tonnes, and earlier in the nineties those four minerals represent about 85 per cent. The total production of industrial minerals has increased by more than 50 per cent since 1987, and amount to almost 6 million tonnes in 1997.

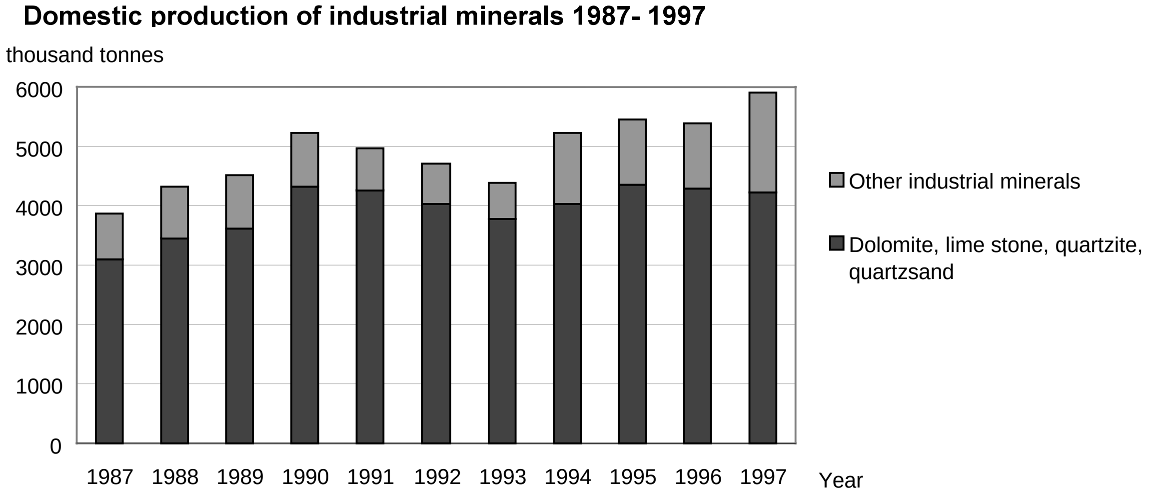

Diagram 4. Domestic production of industrial minerals 1987-1997

Almost half the size of the supply arise from foreign trade, however the imports share decreased during the economic recession in the beginning of the nineties. The total supply of industrial minerals has increased by 2 million tonnes during the observed time period (Diagram 5).

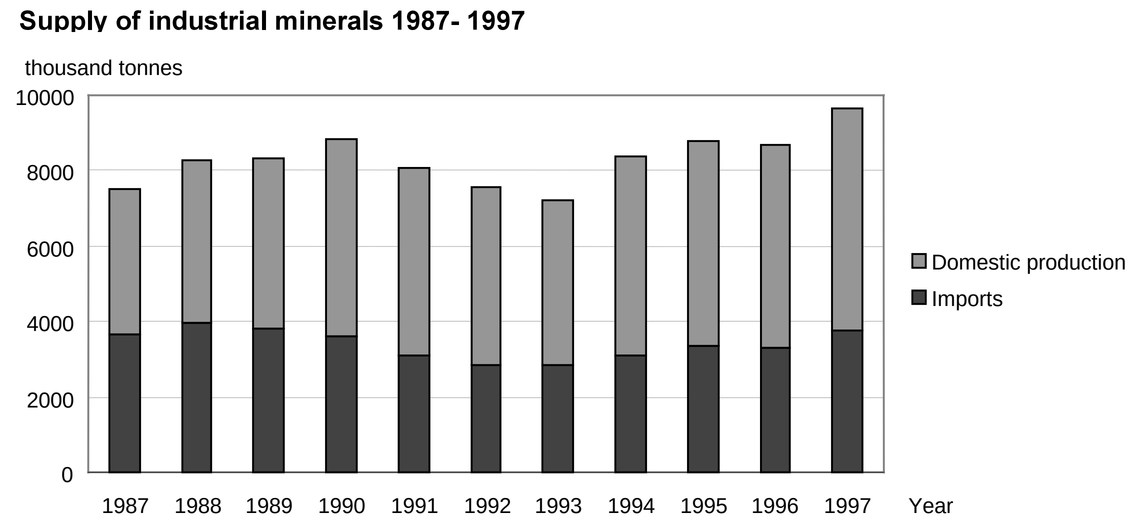

Diagram 5. Supply of industrial minerals 1987-1997, divided into domestic production and imports.

2.1.3.2 Construction minerals

Sand and gravel from natural deposits and crushed bedrock are raw material for the industry of aggregates, also recycled material are used. The extraction of sand and gravel has decreased in Sweden during the nineties, while the production of crushed bedrock has increased. Crushed bedrock's share of the total production of aggregates has almost doubled during the time period. But the total production of aggregates has decreased from 100 million tonnes in the beginning of the nineties to 60 million tonnes in 1997 (Diagram 6).

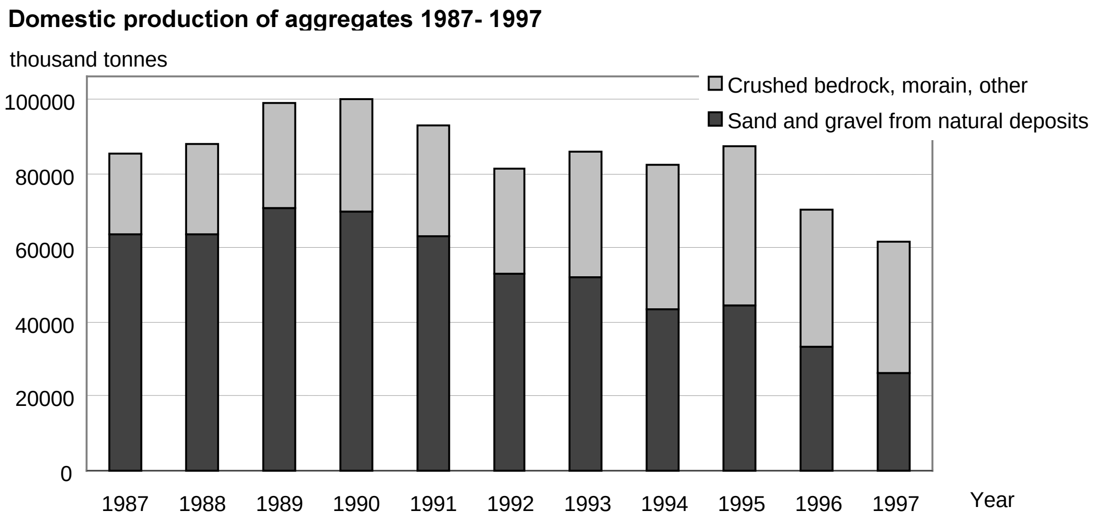

Diagram 6. Domestic production of aggregates 1987-1997, divided into Sand and gravel from natural deposits and Crushed bedrock, moraine, other.

Rocks used in the quarrying industry are granite, gneiss, diabase and quartzite (jointly called granite), slate, limestone, marble, sandstone and soapstone. Natural stone has a great field of application, for example lining and facing houses, paving stone, kerbstone, gravestone.[8] The production of natural stone is insignificant in proportion to aggregates. The production of natural stone however cause large hidden flows. The exchange of natural stone for delivery was only 14 per cent of the total quarrying in 1997.

The domestic production of construction minerals decreased during this time period, likewise imports. Exports doubled since 1987 and amount to 6 million tonnes. The exports share of final demand increased from 3 per cent in 1987 to 9 % in 1997 (Diagram 7).

[8] The Geological Survey of Sweden, 1998. *Industriella mineral och bergarter- en branschutredning.*

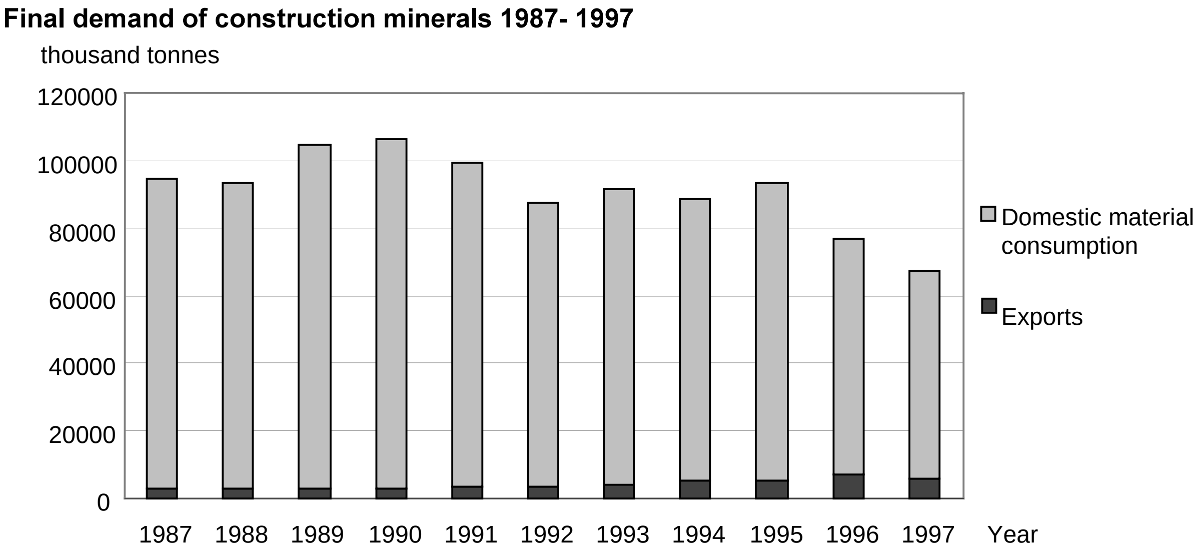

Diagram 7. Final demand of construction minerals 1987-1997, divided into domestic material consumption and exports.

2.2 Renewable materials

Even if a primary product is renewable, unlimited exploitation of a steadily growing population is impossible. Final felling of a forest, for example, means that no significant quantity of new primary products will be obtained from that area of land for the next 60-100 years. Waters can be depleted of fish if fishing is pursued with no thought of economising.

This report on renewable materials covers primary products from forestry, agriculture, hunting and fishing. The quantities reported here refer only to the renewable materials that are harvested for use in the technosphere, excluding additives. For example, we do not take into consideration zinc additives in pig feed or cadmium contained in concentrated feeds.

2.2.1 Forestry

Statistics Sweden's industrial statistics provide data on the industrial consumption of round timber, wood chips and other by-products. These statistics cover only establishments with ten or more year-round employees, and a considerable number of small sawmills and some small wood manufacturing plants are therefore not included in the data. All pulp, paper and board plants are included in the industrial statistics, while other industrial uses are covered only partially; these are, however, relatively limited.

Since the mid-1970s, the various branches of the forestry industry have jointly participated in the collection of information by the Timber Measurement Council on production and consumption volumes among enterprises within the forestry industry. The data shows the consumption at all pulp and board factories, and at all sawmills with an annual production in excess of 1 000 m^3. The volumes consumed by small sawmills are calculated on the basis of stock-taking at sawmills and are reported in the Statistical Yearbook of Forestry (National Board of Forestry). This source also shows felled trees left in the forest, but these are not regarded as part of the flow of materials to the technosphere, since they would have fallen and remained in the forest in the natural course of events too.

Diagram 8. Domestic production of forest products 1987-1997.

The domestic production of forest products has increased during the period, from 45 million tonnes in 1987 to 54 million tonnes in 1997 (Diagram 8).
The diagram 9 below shows the imports of forest products, divided into wood, pulp and paper. Imports of paper has almost tripled since 1987 and amount to 875 thousand tonnes. Imports of pulp has almost doubled since 1987 and amount to 675 thousand tonnes. Imports of forest products has increased from almost 8 million tonnes in 1987 to almost 10 million tonnes in 1997, but decreased to only 5 million tonnes in the beginning of the nineties.

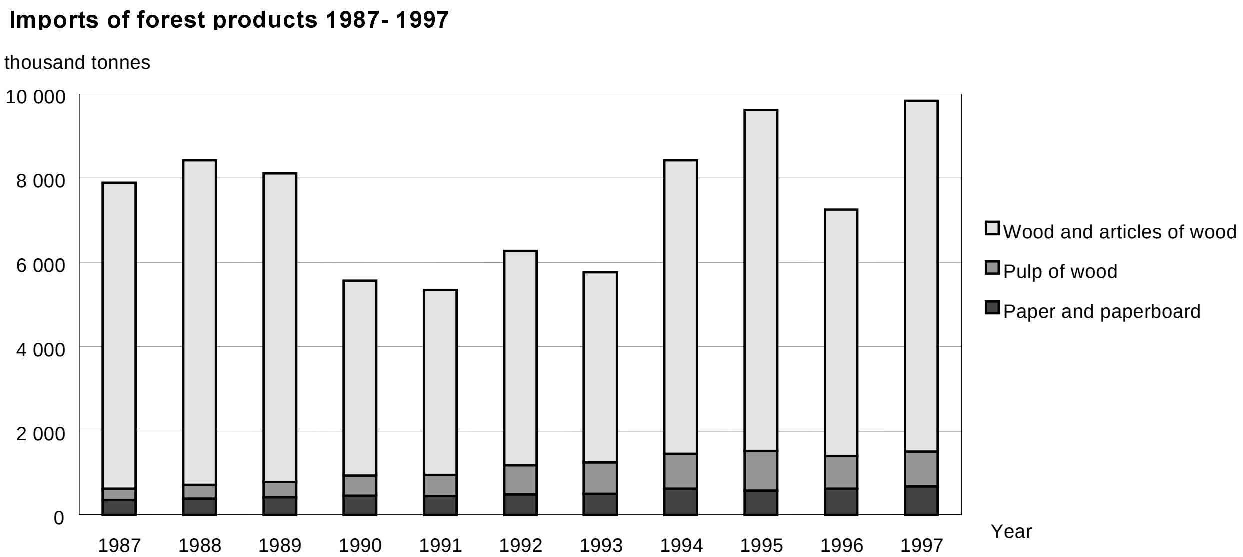

Diagram 9. Imports of forest products 1987-1997, divided into wood and articles of wood, paper and paperboard and pulp of wood.

Below, the exports of forest products, divided into wood, pulp and paper are shown (Diagram 10). Export of forest products has increased from 15 million tonnes in 1987 to 19 million tonnes in 1997. Yearly exports of pulp is 3 million tonnes. Exports of paper has increased during the whole period form 6 million tonnes in 1987 to almost 9 million tonnes in 1997. Exports of wood has increased from almost 6 million tonnes in 1987 to more than 7 million tonnes in 1997, but showed a decrease in the beginning of the nineties.

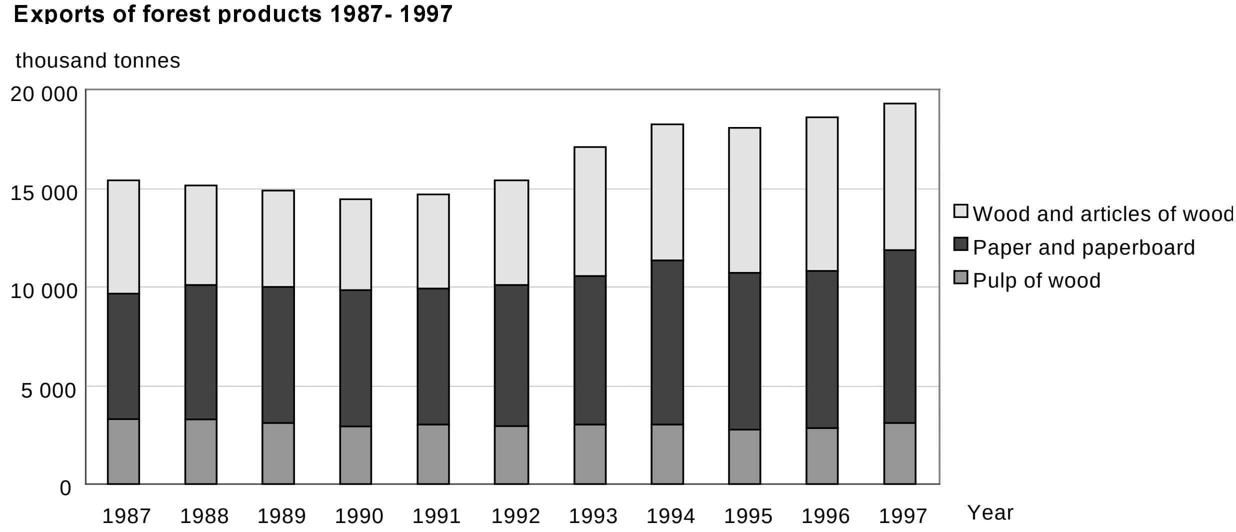

Diagram 10 Exports of forest products 1987-1997, divided into wood and articles of wood, paper and paperboard and pulp of wood.

2.2.2 Raw material for food production

The food referred to in the report consists of beef, pork, lamb, reindeer meat, game, poultry, fish, milk and eggs. Also cereals, fruit and vegetables. With regard to beef cattle, pigs and poultry, we have chosen to show the passage from nature to society by means of the feed they consume. Appendix 1 shows the quantity of feed eaten by beef cattle, pigs and poultry each year. Where sheep are concerned, we have assumed that the bulk of their fodder comes directly from nature, even if some auxiliary feeding generally occurs.

The Swedish University of Agricultural Sciences (SLU) has conversion tables for feed consumption. The number of animals of each type has been ascertained mainly from the Statistical Yearbook of Agriculture, Statistics Sweden.

The yearly domestic production of feed has been almost 8 million tonnes during the whole time period (Diagram 11).

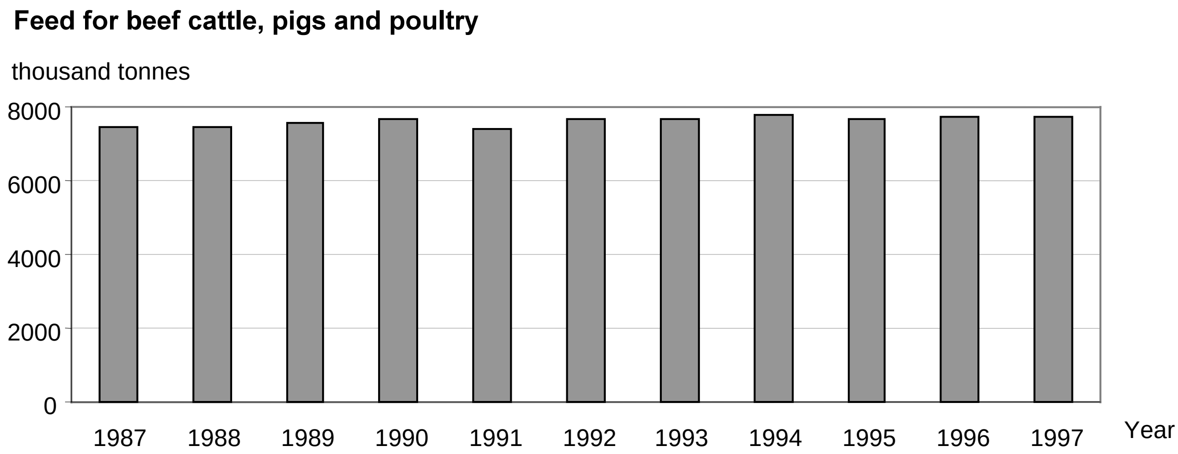

Diagram 11. Feed for beef cattle, pigs and poultry.

Feed for poultry
Statistics Sweden has statistics on chickens for slaughter only up to and including 1995. Since then, sample-based data has been obtained from the Agricultural Register and since there are so few enterprises that keep chickens for slaughter the number turns out too low. Statistics Sweden has therefore chosen not to report information on chickens for slaughter after 1995. However, the company Svenska Fågel has data on the number of chickens reared for slaughter. These figures are however far higher than Statistics Sweden's former figures. Future statistical accounts of material flows might conceivably report feed for poultry based on figures from Svenska Fågel, after scrutinising how they are produced.

Cereals, fruit and vegetables
Yields of cereals are obtained from Statistics Sweden's harvest estimates. For 1988, 1991, 1994 and 1997, information on horticulture has been taken from special horticultural estimates/inventories. Information on home-grown fruit and vegetables is not included.

Fish
The data on commercial fisheries is from Statistics Sweden. Information on the total catch of salt-water fish is based on data collected by Statistics Sweden from authorised primary fish buyers. Some supplementary data has been added on the basis of the statistics that are produced by the National Board of Fisheries and which build on fishermen's logbooks. The fish catch also includes fish landed in Denmark and Norway by Swedish fishermen; these statistics are not included in Statistics Sweden's regular export statistics. The fish landed in Sweden by Norwegian and Danish fishermen, however, is included in Statistics Sweden's import statistics.

Statistics on commercial freshwater fisheries are based on information collected and processed by the National Board of Fisheries. In contrast to salt-water fisheries, where the report is based on information from primary buyers, the figures for freshwater fisheries build on information from individual professional fishermen. The catch here is only about 2 000 tonnes per year.

In 1995, on behalf of the National Board of Fisheries, Statistics Sweden conducted a questionnaire survey on fishing for recreational purposes and household requirements in Sweden. The questionnaire was sent to 6 500 people aged between 16 and 74. The reply rate was 82%. The total catch amounted to 79 000 tonnes (+/- 10 000 tonnes). About 13% of the catch was not kept/ was thrown back. About 60% was caught in the sea and the remaining 40% in inland waters. A corresponding survey was carried out in 1990. The catch at that time was between 34 100 tonnes and 52 700 tonnes.

Hunting
Accounts of meat from hunting have been obtained from the National Board of Agriculture. The National Board of Agriculture receives figures on the shooting of game from the Swedish Association for Hunting and Wildlife Management, but for moose, figures received from the Swedish Environmental Protection Agency are used. The quantity of meat is then calculated on the basis of the number of animals and average weights. The average weight here is the carcass weight.

Wild berries and mushrooms
A study from the late 1970s found the annual supply of blueberries and lingonberries to be around 350-450 million kg/year. Around 5-7%, or approximately 24 million kg, were picked at that time. According to Peter Eliasson, 10 million kg of mushrooms were utilised in 1991 (source: Swedish Environmental Accounts, Peter Eliasson, Umeå University). These estimates are very tentative.

A questionnaire survey conducted by Statistics Sweden in 1995 found that 30 million litres of berries and 14 million litres of mushrooms were picked for household requirements. Almost the same questionnaire survey conducted by Hultman, Swedish University of Agricultural Science in 1977 found that 77 million litres of berries and 22 million litres of mushrooms were picked for household requirements According to calculations in the National Accounts in 1996, sales of domestically produced berries and mushrooms were worth SEK 60 -90 million and those used at home about SEK 170 million.

Honey

The Statistical Yearbook of Agriculture reports figures for the honey harvest. The information comes from the Swedish Association of Beekeepers and is based originally on a postal questionnaire sent to members of the association.

Imports and exports of raw material for food production

Information on imports and exports is taken from Statistics Sweden's statistics on foreign trade. The chapters chosen to be included in raw material for food production are *Chapter 2 Meat and edible meat offal, Chapter 3 Fish and crustaceans, molluscs and other aquatic invertebrates, Chapter 4 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included, Chapter 7 Edible vegetables and certain roots and tubers, Chapter 8 Edible fruit and nuts; peel of citrus fruit or melons*. However, the fish landed by Swedish fishermen in Denmark and Norway, is not included. 1998 for example 141 377 tonnes were landed abroad and are thus not included.

In the analysis it appeared that the category could have been defined wider. The definition could have included the whole *Section I Live animals; animal products* and *Section II Vegetable products* as well as *Section III Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes* and *Section IV Prepared foodstuffs; beverages, spirits and vinegar; tobacco and manufactured tobacco substitutes*. Raw material for food production and Forestry are not the only renewable material flows, an additional category including for example textiles and leather should be added in future studies.

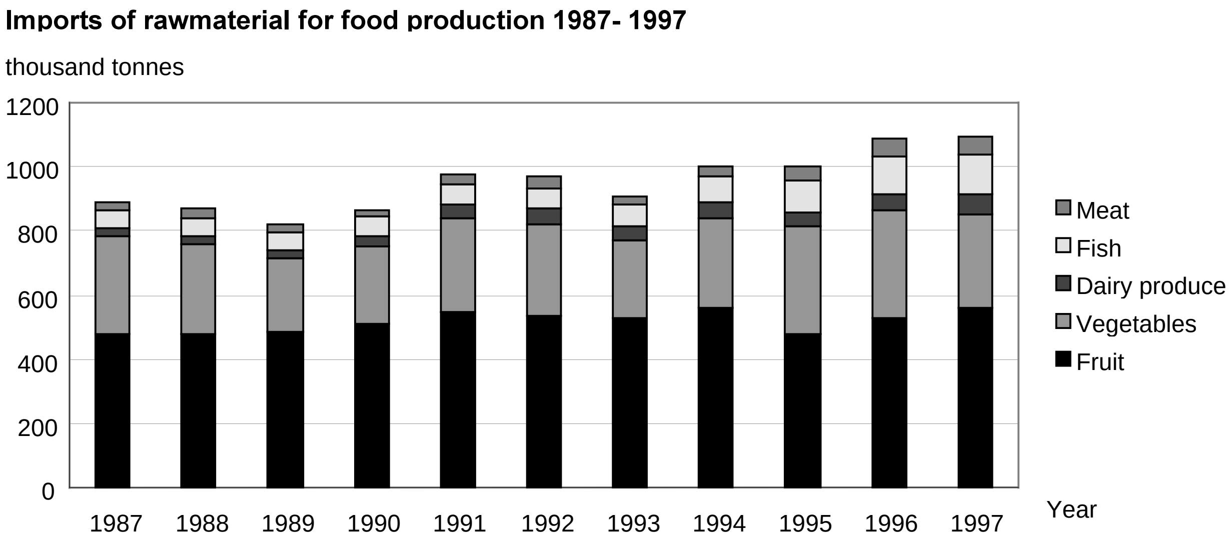

Diagram 12. Imports of raw material for food production 1987-1997, divided into meat, fish, dairy produce, vegetables and fruits.

Above, imports of some foods, divided into meat, fish, dairy produce, vegetables and fruits are shown (Diagram 12). Half the size of the import is fruit, and more than a quarter is vegetables.

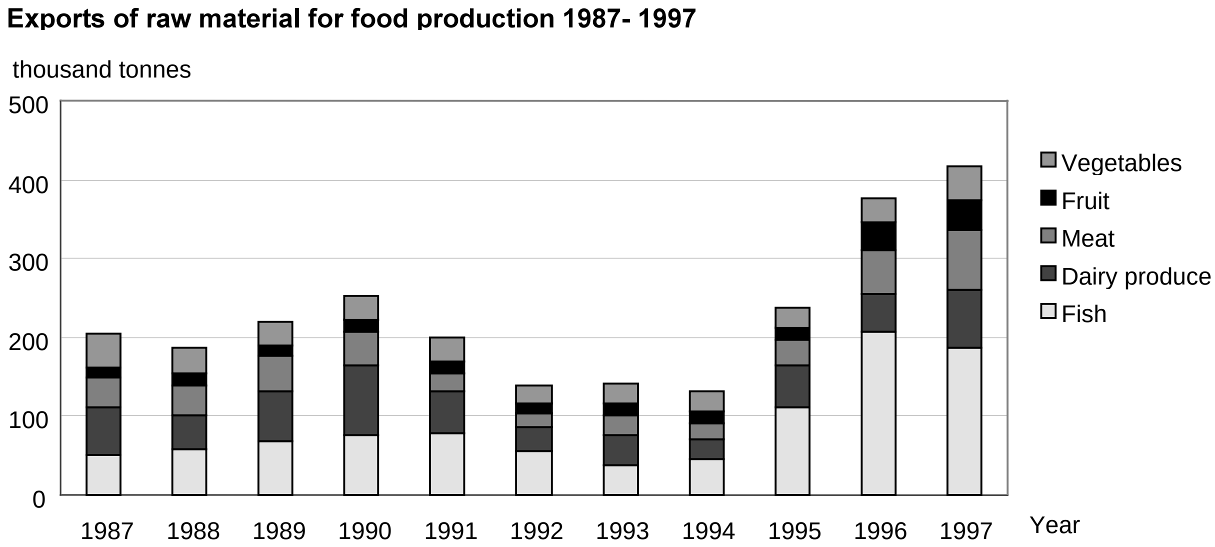

Diagram 13 Exports of raw material for food production 1987-1997, divided into vegetables, fruits, meat, dairy produce and fish.

Diagram 13 shows exports of some foods, divided into vegetables, fruits, meat, dairy produce and fish. The main part of exported foods is fish and dairy products. Exports of foods has doubled since 1987 and amount to 400 thousand tonnes, but decreased during the early nineties.

2.3 Total direct material input (DMI)

2.3.1 Material flows in the Swedish economy 1997

The total material flows consist of one third renewable materials and two third non-renewable materials. Note that 20% of the non-renewable materials are fossil fuels. Construction minerals cause the largest material flow, followed by forestry and ores. Domestic production in Sweden consists mainly of construction minerals, ores and forestry. Construction minerals are consumed in Sweden, while ores and forest products are exported to a large extent. Seventy per cent of the Swedish exports consist of ores and forestry.

The Swedish imports consist mainly of fossil fuels. The greater part of raw material for food production come from domestic production, only a small amount is imported. The use of raw material for food production is mainly domestic material consumption, only a small part is exported.

One third of the domestic material consumption is renewable materials, mostly forestry. Construction minerals also stand for one third of the domestic material consumption. Twenty percent of the non-renewable materials consumed in Sweden are fossil fuels not stored in society, but consumed and dispersed as carbon dioxide.

2.3.2 DMI per capita

DMI per capita is around 28 tonnes per capita for the period 1987-1998, with highest values 1989 and 1995 (Appendix 3). The fossil fuel input varies only slightly over the period, from 3,2 tonnes/ capita in 1991 to 3,6 in 1996. Renewable raw materials vary between 7,9 and 9,1 tonnes/ capita (Diagram 14). The non-renewable categories ores and minerals vary between 14,8 and 18,8 tonnes/ capita.

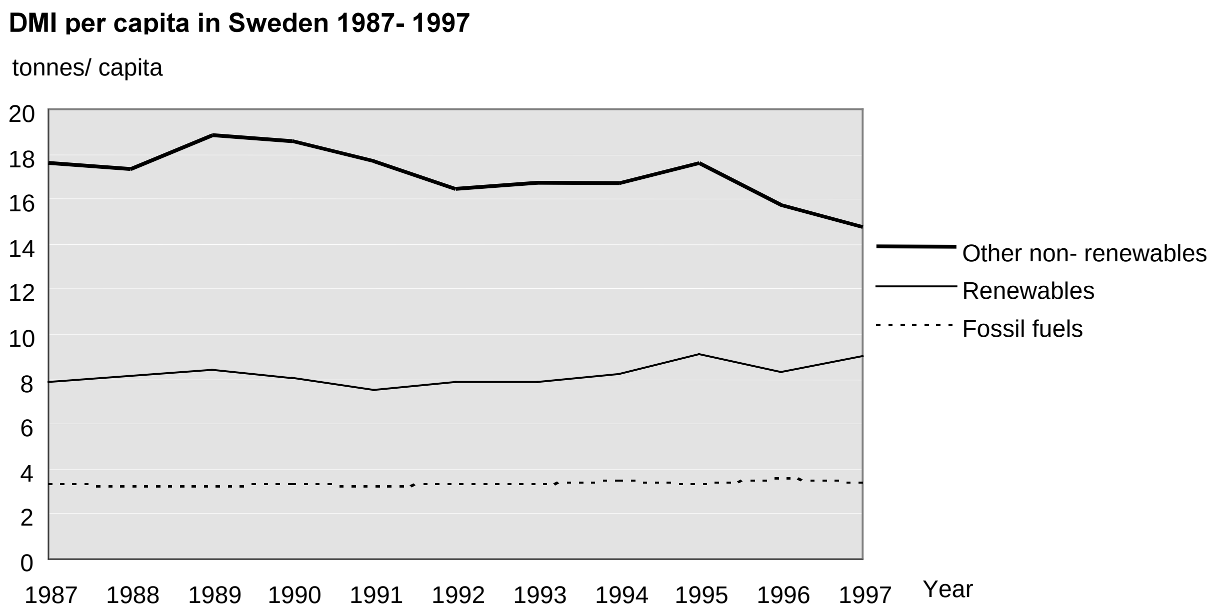

Diagram 14 DMI per capita in Sweden 1987-1997, divided into renewables, fossil fuels and other non-renewables.

2.3.3 International comparisons

This calculation puts Sweden above the estimates made for Germany, USA and Japan, and in the same size as the Netherlands. There are several explanations for the differences. Differences can be explained by system boundaries, by data sources and by how the exports are treated. In the table (Table 2) below the comparisons are shown.[9] The Swedish DMI/ capita is compared with 'commodity/ capita' in the international study. The flow types in the international study are said to be direct and hidden flows, even though the headings in the compared table says commodity/ capita, we assume it is comparable to what we call DMI/ capita. For the Netherlands, we have chosen not to compare the disaggregated figures, as we are informed that they are partly erroneous. For the total DMI, Sweden and the Netherlands appear to be of the same size however.

For the fossil fuels, Sweden and Japan have similar per capita figures of about 3 tonnes/capita. The industrial minerals are also on the same level as the other countries.

For the construction minerals, Sweden has a high figure. This can be explained by what statistics have been available, as the economic statistics may have different system boundaries than what is wished for. In this study, raw material statistics was often taken from other sources than the industrial statistics. Earlier studies[10] have shown that construction materials are underestimated in the Swedish industrial statistics, as the cut-off on numbers of employees have excluded many small companies.

For the renewable materials, Sweden's per capita input appears to be about 5 tonnes higher than the other countries, which is probably explained by the dominating forest industry.

The system boundary chosen for the ores has a major impact on the results. The international comparison made it clear that earlier studies have had a boundary different to the one chosen in this study. In the international study we believe that *the concentrates* of metals have been considered direct flows, while we have considered *the ores* (but excluded the rock) as direct flows.

If a calculation is based on concentrates the resulting figures become much lower, between 2,0 to 2,8 tonnes/capita over the time period (Table 3). Even if we here present figures that can be compared to the international figures, the main text of the report is still based on ores as direct flows. This can be recalculated in future work.

	DMI/ capita				**DMC/ capita**
	USA	**Japan**	**Germany**	**Sweden**	**Sweden**
Non-renewables					
Fossil fuels	8	3	6	3,2	2,3
Ores	1	1	1	5,3 (2,0)	2,9 (0)
Industrial minerals	0	2	1	0,9	0,8
Construction minerals	7	9	10	11,5	11,1
Total non-renewables	**16**	**15**	**18**	**20,9 (17,6)**	**17,1 (14,1)**
Renewables					
Raw material for food production				1,6	1,5
Forestry				5,9	4,2
Total renewables	**4**	**2**	**3**	**7,5**	**5,8**
Total non-renewables and renewables	**20**	**17**	**21**	**28,4 (25,1)**	**23,0 (20,0)**

Table 2 DMI in tonnes per capita for USA, Japan, Germany and Sweden in 1991.
Note: figures in brackets refer to ores re-calculated as concentrates

[9] World Resource Institute et al, 1997. *Resource flows: The material basis of industrial economies.*
[10] Bergstedt E. and I. Linder,1999. *A Material Flow Account for Sand and Gravel in Sweden.*

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Production											
Non-ferrous ores	1 308	1 129	1 003	956	833	837	791	736	757	703	752
Iron ore	14 051	13 547	13 799	12 626	12 599	13 593	13 597	14 123	16 686	17 527	18 031
Imports	5 071	5 572	5 512	4 700	4 279	4 391	4 744	5 864	5 560	5 333	6 000
DMI/ capita	2,4	2,4	2,4	2,1	**2,0**	2,2	2,2	2,4	2,6	2,7	2,8

Table 3 DMI per capita of ores, when production figures is from concentrates.
Source: Statistics of the Swedish mining industry 1997, The Geological Survey of Sweden

2.4 Domestic material consumption (DMC)

In order to distinguish the domestic material consumption, DMC,[11] DMI have also been complemented with export figures. This is made in order to single out the input for national consumption, from the input used in production for export purposes. Sweden is dependent on its export of raw materials such as ores and pulp. If consumers in Sweden would become more resource efficient, while the exports of raw materials to other countries increased, it is important that our measures on resource use can distinguish between these phenomena.

Final demand is presented as national consumption and exports. National consumption is defined as domestic production plus imports minus exports. This estimate has its limitations and ought to be refined in future work. As the exports are refined goods compared with the raw materials, e.g. pulp and paper instead of wood, domestic material consumption is most probably overestimated.

Below, domestic material consumption during 1987 to 1997, divided into renewables, fossil fuels and other non renewables is shown (Diagram 15). Domestic material consumption varies between 21 and 25 tonnes per capita during the time period. The domestic material consumption of fossil fuels varies between 2,2 and 2,6 tonnes per capita during the time period. Renewables varies from 5,8 tonnes per capita to 7,1 tonnes per capita. Domestic material consumption of non-renewable materials (excluding fossil fuels) has decreased during the period from the highest value 15,8 tonnes per capita in 1989 to 11,3 tonnes per capita in 1997.

As can be seen in the following figures (Diagram 16, 17 and 18), exports play an essential role in the national DMI. Therefore, it would be important to be able to single out its effect. Especially for small countries such as Sweden or the Netherlands the effect of export goods may dominate international comparisons between countries. To be able to assess the resource input for consumption, export will have to be subtracted from the DMI.

[11] see for example IFF, 1998. *Are industrial economies on the path of dematerialization? Material Flow accounts for Austria 1960-1996: Indicators and international comparison.*

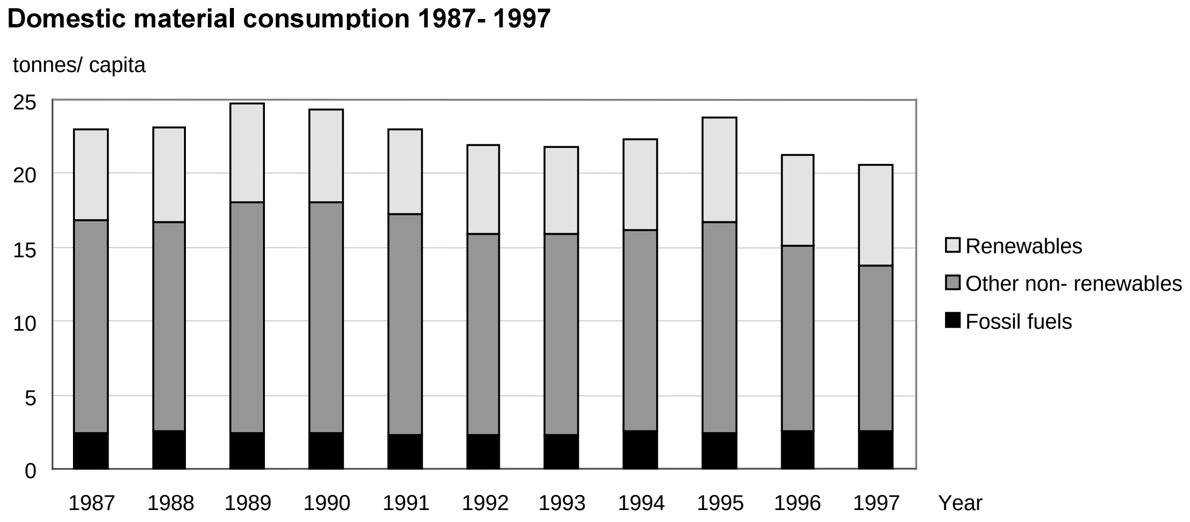

Diagram 15 Domestic material consumption 1987-1997, divided into renewables, fossil fuels and other non-renewables.

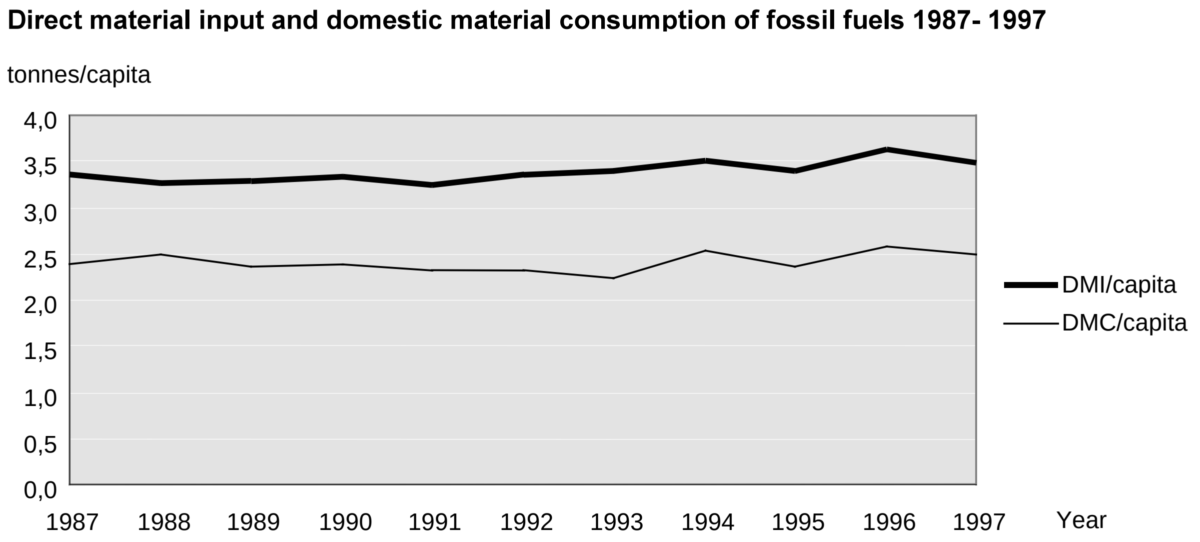

Diagram 16 Direct material input and domestic material consumption of fossil fuels 1987-1997, shown as tonnes per capita.

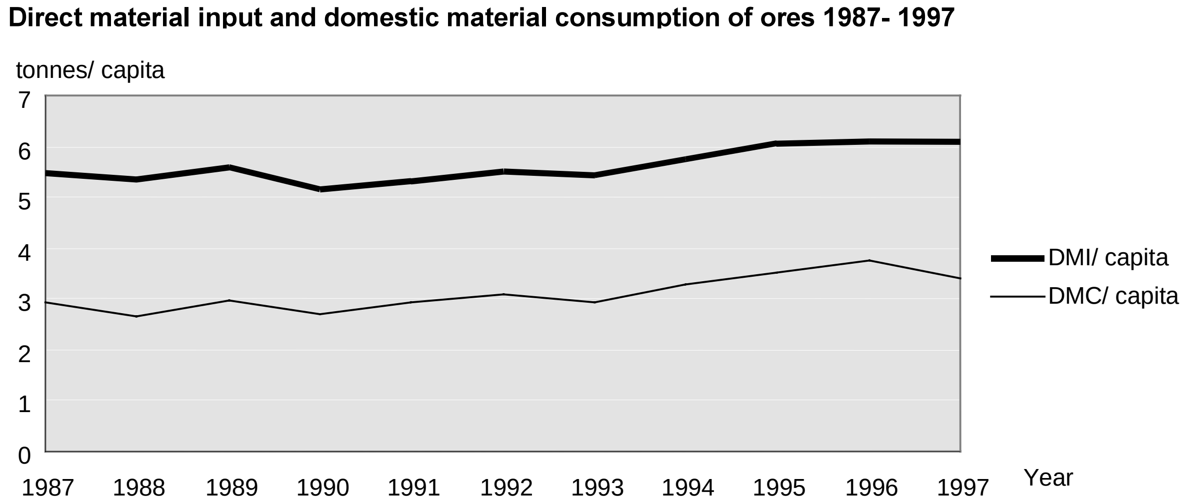

Diagram 17 Direct material input and domestic material consumption of ores 1987-1997, shown as tonnes per capita.

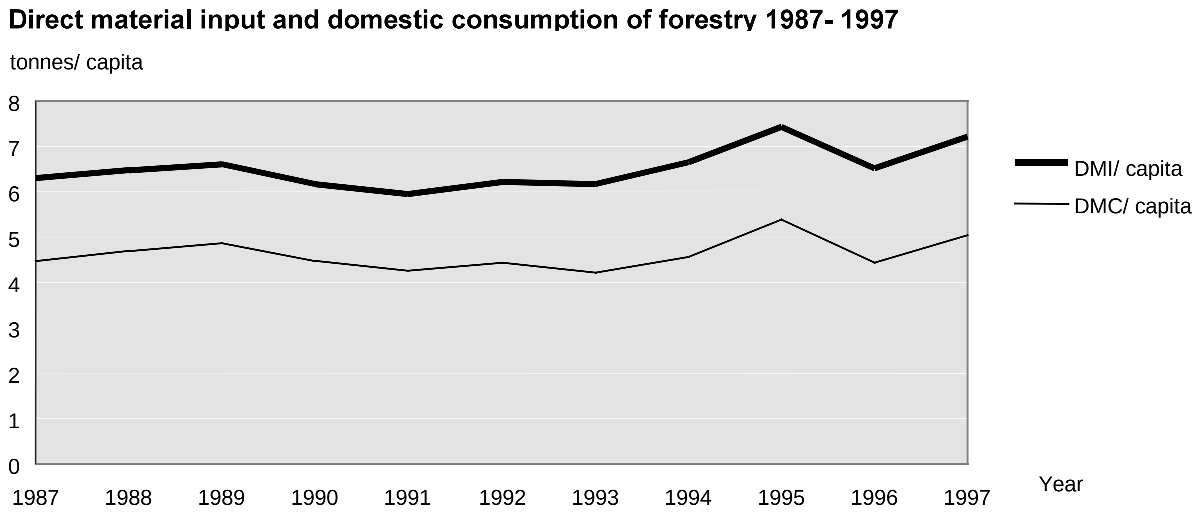

Diagram 18 Direct material input and domestic material consumption of forest products 1987-1997, shown as tonnes per capita.

3 Output from the environmental accounts: air emissions and waste

Material flow analysis at Statistics Sweden (SCB) is developed mainly within the frames of environmental accounting. In 1992, SCB was commissioned by the Government to develop Physical Environmental Accounts. The Swedish environmental accounts includes themes such as energy, material flows, work force, environmental taxes, stocks and quality of natural resources, emissions and waste.

The Swedish Environmental and Economic Accounts (SWEEA, Statistics Sweden and National Institute of Economic Research, 1994) is mainly based on the United Nation framework (SEEA, United Nations, 1993) and the NAMEA-model developed in the Netherlands (de Boo et. al. 1991 and de Haan, et. al. 1993, CBS). In the following sections some of the statistical material in the environmental accounts is presented.

3.1 Emissions of sulphur dioxide, nitrogen oxides, carbon dioxide

Emissions of sulphur dioxide, nitrogen oxides, carbon dioxide originate from three main sources:

- combustion in the generation of energy and heat
- transportation (road, air, rail, sea, off-road vehicles, motorised equipment)
- industrial processes (manufacture of various goods)

Emissions of *sulphur dioxide* mainly come from the combustion of oil products and from industrial processes. Emissions from combustion depend both on the sulphur content of the fuel and on any purification measures involved.

For *nitrogen oxides*, the main source of emissions is transportation. These emissions depend not only on the amount of fuel consumed, but also on the combustion conditions, i.e. the oxygen availability, temperature and purification. This is taken into account in the emission factors and computation methods employed.

Emissions of *carbon dioxide* largely come from combustion and are proportional to the carbon content of the fuel.

All the energy-related emissions have been calculated on the basis of data on the consumption of different types of energy in different sectors that have been drawn up in the energy accounts for the Swedish NAMEA. Information on process emissions of the above substances has been provided by the Environmental Protection Agency, which uses a classification system based on the Environment Protection Act rather than the international standard classification system for industries (the Swedish SNI, compatible with NACE Rev. 1) that is used in the economic statistics.

In the table below the emissions from e.g. transportation are registered under the sector that performs the transport, i.e. mainly the transport industry (the emission computations are based on consumption of fuel per industry and, for NOx, for the sector in which the vehicles are registered). It is therefore not possible to see the extent of emissions generated by the food sector, for instance. By using the registration of payment flows between different sectors in the input/output system it is possible to obtain figures on such emissions, as will be done below.

Table 4

Emissions of CO_2, SO_2 and NO_x from different sources and energy consumption by kind of economic activity of industries, government services and private consumption in 1993. Thousand tonnes

	CO_2				SO_2				NO_x			
	Total	of which			Total	of which			Total	of which		
	excl. biofuel	stationary combust.	mobile combust.	industrial processes		stationary combust.	mobile combust.	industrial processes		stationary combust.	mobile combust.	industrial processes
Agriculture	1 377	433	944	-	1	0	0	-	19	0	19	-
Forestry	424	47	377	-	0	0	0	-	14	0	14	-
Fishing	157	0	157	-	0	0	0	-	5	0	5	-
Mining, quarrying	441	344	96	0	3	1	0	2	5	1	1	2
Manufacturing, total	17 775	13 132	739	3 903	49	11	0	38	49	16	10	23
food, textile, wood, mineral	*4 661*	*2 406*	*284*	*1 972*	*12*	*3*	*0*	*9*	*16*	*8*	*2*	*6*
pulp, paper, printing	*1 972*	*1 860*	*81*	*31*	*18*	*5*	*0*	*13*	*16*	*5*	*2*	*9*
chemicals and plastics	*2 025*	*474*	*47*	*1 504*	*4*	*1*	*0*	*3*	*4*	*1*	*2*	*2*
petroleum products	*1 739*	*1 739*	*0*	*0*	*6*	*0*	*0*	*6*	*4*	*0*	*1*	*3*
iron and steel	*6 374*	*5 941*	*36*	*397*	*9*	*1*	*0*	*8*	*7*	*1*	*2*	*4*
machinery and equipment	*1 005*	*713*	*292*	*0*	*1*	*1*	*0*	*0*	*3*	*1*	*2*	*0*
Electricity, gas, district heating	8 893	8 732	161	-	15	15	0	-	16	15	1	-
Water and wastewater treatment	20	2	18	-	0	0	0	-	1	0	1	-
Construction	1 466	391	1 075	-	0	0	0	-	6	0	6	-
Transport	11 892	0	11 892	-	22	0	22	-	120	0	120	-
Dwellings and premises	717	644	73	-	1	1	0	-	2	1	2	-
Trade and services	3 416	1 556	1 860	-	1	1	0	-	56	1	54	-
Total industry	46 579	25 283	17 392	3 903	92	29	23	40	292	35	231	26
Governmental production	1 994	958	1 036	-	1	1	0	-	3	1	2	-
Private consumption	14 749	4 621	10 128	-	6	5	1	-	102	6	96	-
Total	63 322	30 862	28 557	3 903	99	34	25	40	396	42	328	26

3.2 Waste

Waste statistics for the extraction and manufacturing industries in 1993 are included in the environmental accounts. A waste survey was conducted in 1994, and the statistics was collected directly according to economic classifications. The information was gathered via questionnaires to selected workplaces in industry. It is difficult to define and measure waste in industry, which means that the figures should be treated with great caution. The data can be presented in at least two different ways. Different sorts of waste can be studied, for example hazardous waste or industry specific waste groups, like in table 5. Or, the total amount of waste could be grouped according to treatment method applied, see table 6.

The extraction industry dominates the total waste amounts for the studied industries. The waste from this industry is about three times as much as that from all manufacturing industries together. The extraction industry is not included in table 5 or 6.

	Waste		of which					
	thousand tonnes	% of total waste	Industry specific	% of industry specific	Household	% of house-hold	Hazardous	% of hazardous waste
Food industry	1 318	9	988	7	28	22	1	0
Textile and leather	37	0	31	0	2	2	0	0
Wood	6 716	45	6 686	48	5	4	2	1
Pulp, paper, printing	2 804	19	2 654	19	17	14	14	7
Chemicals and plastics	368	2	251	2	8	6	38	20
Petroleum products	11	0	4	0	2	2	4	2
Mineral	628	4	531	4	4	4	4	2
Iron and steel	2 259	15	2 168	16	11	9	63	32
Machinery and equipment	753	5	520	4	44	35	69	35
Other manufacturing	151	1	145	1	4	3	0	0
Total	15 045	100	13 979	100	126	100	196	100

Table 5 Waste and some waste groups in manufacturing industry, 1993. Thousand tonnes, differences due to rounding.

	Waste		of which							
	thousand tonnes	% of total waste	Landfill thousand tonnes	% of landfill	Incine-ration with energy-recovery	% of incine-ration	Reco-very thousand tonnes	% of reco-very	Other treat-ment thousand tonnes	% of other treatment
Food industry	1 318	9	445	16	38	1	641	11	125	10
Textile and leather	37	0	30	1	1	0	3	0	1	0
Wood	6 716	45	83	3	2 825	65	2 452	44	623	51
Pulp, paper, printing	2 804	19	964	34	1 242	29	429	8	115	9
Chemicals and plastics	368	2	133	5	38	1	120	2	23	2
Petroleum products	11	0	3	0	1	0	0	0	2	0
Mineral	628	4	392	14	7	0	214	4	8	1
Iron and steel	2 259	15	530	19	4	0	1 404	25	257	21
Machinery and equipment	753	5	222	8	35	1	330	6	68	6
Other manufacturing	151	1	4	0	143	3	3	0	1	0
Total	15 045	100	2 805	100	4 333	100	5 594	100	1 224	100

Table 6 Waste and treatment methods in manufacturing industry, 1993. Thousand tonnes, differences due to rounding.

3.3 How does material input relate to output-related environmental data?

Material production is closely connected to environmental pressure:

- Mining and metal processing are energy and waste intensive activities
- Production of paper is an also energy intensive activity, but less carbon dioxide intensive than the metal industry, since biofuels are used to a high extent. The emissions of sulphur dioxide from the pulping industry are also relatively large compared to other industries.
- The production and distribution of food is energy intensive. Emissions of nitrogen are strongly coupled to food production and consumption. Agriculture and waste water treatment contribute to nitrogen emissions to water, and the distribution chain contribute to nitrogen emissions to air.
- Production of cement is energy intensive and can be a sulphur oxide intensive activity largely depending on the raw material.

Below, a method is tested in order to redistribute material input and environmental pressure from branches of industry to product groups. A monetary input-output analysis is used. Since the system boundaries for the monetary flows and the physical flows differ in many aspects, this is a first test to see how the results correspond to known relationships. To our knowledge, this type of comparison have not been performed before.

Input/output analysis: branches and products

The project includes time series of material flow input from 1987-1997. To facilitate a comparison between different sectors of society, these flows are classified according to the NACE system for industries. As this is the classification system used for all parts of the environmental accounts there is a link between material flows, energy use, value added, final demand, emissions etc.

Input-output analysis is based on an input-output table. An input-output table describes inter-industrial relations as well as value added and final demand. The rows of the input-output table show the sales of the total production of an industry to other industries and final demand. Final demand typically consists of private and government consumption, export and investment.

In the columns of the table, total inputs in an industry are recorded. These are intermediate inputs, that are the purchases from other industries, and primary inputs, such as taxes, labour costs, profits etc. In this way, a complete picture of the production structure of the economy is obtained. The total outlays of each industry equals the total revenue per definition, so that the corresponding row and column totals of the input-output table are equal (for more discussion of input-output analysis, see e.g. Konijn, 1994).

The monetary input-output tables were primarily designed to investigate economic relationships. In this application we are interested in the allocation of physical quantities between industries and final demand, and use the monetary interdependency as an allocation tool. This means that we assume that the physical flow is proportional to the monetary flow. Apparently this is a very strong assumption, at least on the level of aggregation used (45 industries). A more disaggregated input/output table would probably permit a more detailed decomposition of the flows in terms of volumes, prices, imports etc.

Materials input coefficients are formed by dividing the quantities of the different materials that enter the economy through different industries, by the total production value of these industries. The coefficient thereby describes how many tonnes of a material that each produced MSEK in that industry is associated with. The relationship is linear, i.e. if production in the industry doubles in MSEK, the input of the material in tonnes doubles too.

This makes it possible to allocate the materials entering into the economy by one or several industries, to the outputs of one or several industries in the economy. Input/Output (I/O) analysis is mostly used to study how changes in final demand for a particular commodity induce changes in production in all, or specific, industries. This is done by using the so called Leontief matrix, that translates a certain final demand into the production volume (in monetary terms) required to meet this specific final demand. For example, 100 MSEK of final demand on output from the car manufacturing industry requires not only production in that industry, but also in all other industries that produce intermediary inputs to the car industry. These in turn need inputs from other industries, including the car manufacturing industry, to be able to produce the inputs they sell to the car manufacturing industry etc. This then continues in an infinite number of rounds.

All in all, 100 MSEK of final demand for the output from the car manufacturing industry will require a production value in that industry and many others, of well over 100 MSEK. With every MSEK of production, in the industries that are the entry point for materials, a certain amount of materials is used. Summing up over all the rounds it is then possible to come up with a figure of the volume of different materials used in meeting a final demand from the car manufacturing industry of 100 MSEK.

Results from the material allocation

The results presented for material flows from the final demand side thus show the material inputs necessary to produce the total outputs delivered to total final demand, in the different stages of the production process for every industry involved.

The results are presented in Table 7. Different raw materials have been allocated on branches of industry by means of input-output analysis. Unfortunately, because of the level of aggregation of the monetary input-output table, ores and industrial minerals could not be separated. Construction minerals were allocated to branch 26, ‘manufacture of other non-metallic mineral products’, in order to separate them from ores and industrial minerals. This problem, that the monetary tables could not single out such different industries, could not be solved in this project.

The results show that a few industries account for the main part of the flow, as could be expected. Most of the materials are allocated to the industry where they were produced. This means that they have been sold for final demand direct from that industry, which often implies export as raw material. Some of the allocations are difficult to explain however, particularly for the category construction minerals. The category ‘Governmental services’ appears rather material intensive. This is probably partly because it is a large aggregate, with a high weight in monetary flows. By looking at the results in closer detail (not shown) it is also evident that some imported materials ought to have been included, such as for example textiles, rubber and tobacco.

NACE Rev. 1		Fossil fuels	Ores & Indust. mineral	Construction minerals	Forestry	Raw material for food production Vege-tables	Fish
01	Agriculture, hunting and related service activities	0	0	0	0	20	1
02	Forestry, logging and related service activities	0	0	0	12	0	0
05	Fishing, operation of fish hatcheries and fish farms	0	0	0	0	0	65
10-14	Mining of coal and lignite; extraction of peat etc., Mining of metal ores and other mining and quarrying	0	55	0	0	0	0
15	Manufacture of food products and beverages	4	1	3	1	63	21
20.1	Sawmilling and planning of wood, impregnation of wood	1	0	0	31	0	0
20 other	Manufacture of wood and products of wood and cork	0	0	2	2	0	0
21	Manufacture of pulp,	1	0	0	11	0	0
21 other	Manufacture of paper and paper products	2	2	1	23	0	0
22	Publishing, printing and reproduction of recorded media	0	0	0	1	0	0
23	Manufacture of coke, refined petrol. prod., nuclear fuel	53	1	0	0	0	0
24.4 -5	Manufacture of pharmaceuticals, medicinal, chemicals and botanical products. Manufacture of soap and detergents, clean. and polish. preparations, perfumes and toilet prep.	1	0	1	0	0	0
24 other	Manufacture of chemicals and chemical products	2	1	0	0	0	0
25	Manufacture of rubber and plastic products	0	0	0	0	0	0
26	Manufacture of other non-metallic mineral products	0	2	34	0	0	0
27	Manufacture of basic metals	1	10	3	0	0	0
28	Manufacture of fabricated metal products	1	1	1	0	0	0
29	Manufacture of machinery and equipment	2	2	2	1	0	0
30	Manufacture of office machinery and computers	0	0	0	0	0	0
31 -32	Manufacture of electrical machinery and apparatus n.e.c. Manufacture of radio, television etc.	2	2	3	1	0	0
33	Manufacture of medical, precision and optical instruments, watches and clocks	0	0	1	0	0	0
34-35	Manufacture of motor vehicles, trailers and semi-trailers Manufacture of other transport equipment	2	2	5	1	0	0
36-37	Manufacture of furniture; manufacturing n.e.c. Recycl.	0	1	1	1	0	0
40	Electricity, gas, steam and hot water supply	1	1	1	2	0	0
41	Collection, purification and distr. of water, sewage disposal	0	0	0	0	0	0
45	Construction	3	5	18	3	0	0
50-52 other	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and households goods	5	1	2	1	1	1
55	Hotels and restaurants	1	0	2	0	4	4
60.2-60.3	Other land transport, Transport via pipelines	2	0	0	0	0	0
61	Water transport	1	0	0	0	1	7
62	Air transport	1	0	0	0	0	0
63	Supporting and auxiliary transport activities	0	0	0	0	0	0
64.1	Post	0	0	0	0	0	0
64.2	Telecommunications	0	0	0	0	0	0
65+67.1	Banks and other financial institutions,	1	0	0	0	0	0
70a	Small house and holiday cottages	1	1	4	1	0	0
70b	Real estates	2	2	3	1	0	0
71-74	Renting companies	2	0	1	1	0	0
	Governmental services	7	7	9	3	7	4

Table 7. Material for end use 1995. Percentage

A similar input-output analysis was performed for the output parameters air emissions and hazardous waste. The sulphur emissions are expected to follow forestry products, fossil fuels and cement production. The nitrogen emissions are expected to follow the consumption of fossil fuels in transportation. The results from the calculation of ores and industrial minerals from Table 7 are tabulated together with the output parameters (Table 8).

The connections between material flows and energy consumption can be traced in Table 8. We see that 55% of the materials from the mines are exported (and therefore counted as final demand) directly, without processing. This explains why the environmental parameters are relatively low in the first row.

Manufacturers of basic metals show significant contributions both for material input, carbon dioxides and hazardous waste. For many rows in Table 8 the percentage of carbon dioxide and material input of ores and industrial minerals are correlated.

Some deviations can be explained by other material flows. Governmental services have higher carbon dioxide and nitrogen oxide values, possibly depending on the transport intensity, which is not related to ores. The same is probably the case for ‘Manufacture of food production and beverages’ at the last row. ‘Electricity, gas, steam and hot water supply’ (40) has a connection to fossil fuels, which may explain their environmental parameters. These figures need closer analysis, as the allocation of fossil fuels on product groups is rather complicated.

‘Manufacture of paper and paper products’ (21) stands out , but has a connection to renewable material flows (of forestry, 23% as shown in Table 7).

Hazardous waste is high from certain types of industries, such as metal manufacturing (27) and manufacture of chemicals (24), as expected.

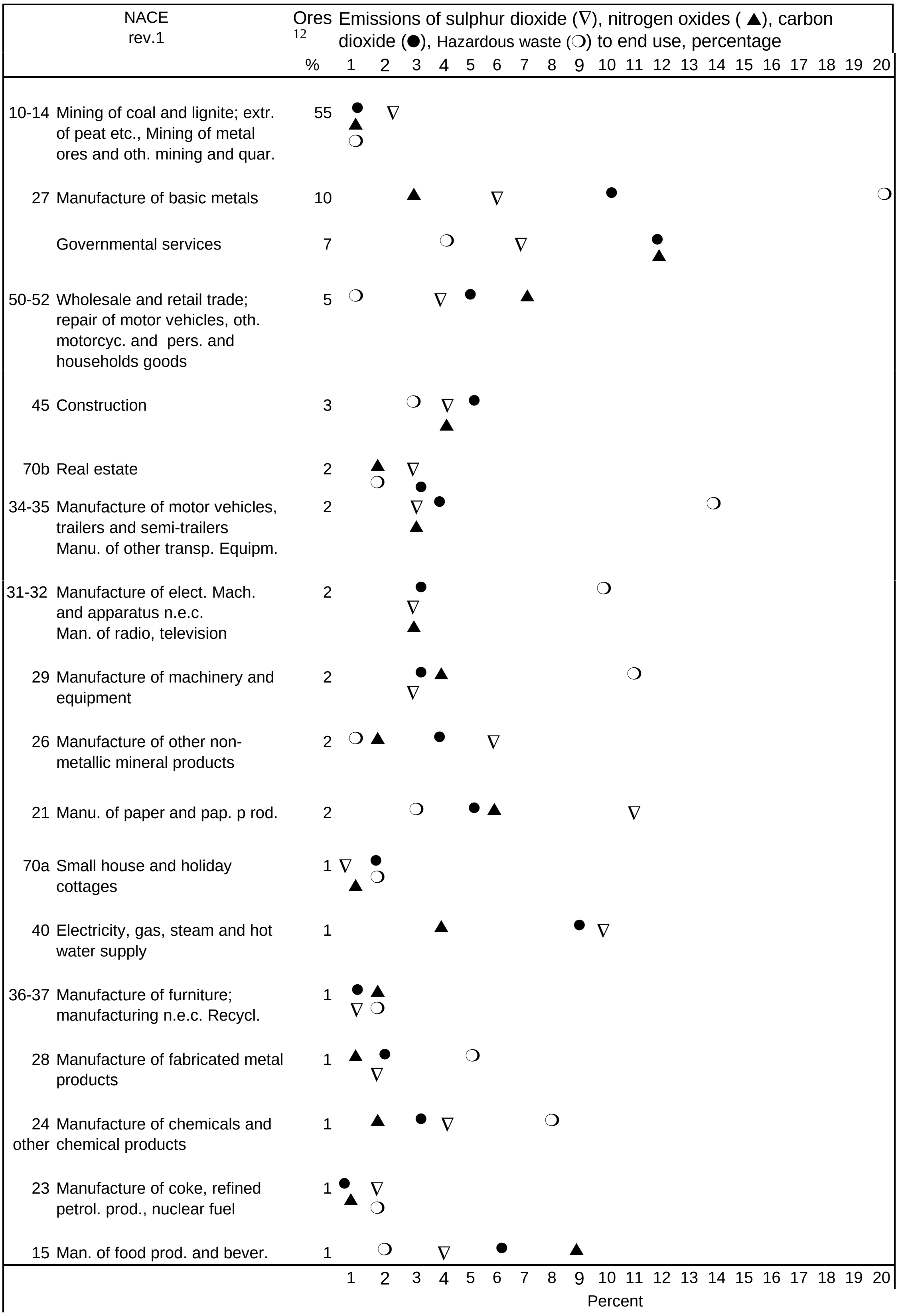

Table 8. Ores and industrial mineral to final demand, percentage (the kind of economic activity of industries sorted by descending order) and final demand of emissions of sulphur dioxide, nitrogen oxides, carbon dioxide and hazardous waste, percentage.

[12] Ores and industrial mineral

4 Discussion

The results presented here would be of interest to use in a deeper comparison with international studies. We see a need to define the system boundaries for what is to be called a 'direct' flow from mining. In the future we would also like to recalculate some of our results with a more narrow definition than what was done in the major parts of this study.

As has been mentioned earlier, the importance of separating exports from domestic material consumption is stressed in this study. To present a measure that includes both production, imports and exports will make international comparisons difficult to interpret. By separating the domestic material consumption from the exports this problem can be overcome. However, some more work is needed to express the exports in terms of raw materials, in order not to overestimate domestic material consumption.

The availability of data has been better than what we first expected. The comparisons made between input data and emissions seems promising, and deserve more thought and more thorough examination.

The use of monetary input/output tables to trace a physical flow is not without its problems. It is a second best solution, as a physical input/output table would most likely be preferable. This is one of the major methodological issues that will have to be dealt with in further studies as it concerns the different system boundaries between the monetary data and the physical data, and the potential effects on the results.

We have tried to estimate differences between physical flows and monetary flows by comparing the calculated results with other available statistics for fuels. The results (not shown) point to problems concerning energy intensive industries, such as the energy sector and steel manufacturing. Further studies are obviously needed in order to provide us with the tools for allocating physical flows over industries or commodities, with better precision. One of these tools will most likely be disaggregated monetary input/output tables.

Other methods that could be available are physical input/output analysis, substance flow analysis and life cycle analysis. They can give complementary information on essential details of the system. If the goal is to be able to trace a nations total raw material consumption, the data gathering may be too costly. Therefore, methods to refine the monetary input output table for this particular use would be of interest.

5 Conclusions

DMI per capita is around 28 tonnes per capita for the period 1987-1998, with highest values 1989 and 1995. The fossil fuel input varies only slightly over the period, from 3,2 tonnes/capita in 1991 to 3,6 in 1996. Renewable raw materials vary between 7,9 and 9,1 tonnes per capita. The non-renewable categories ores and minerals vary between 14,8 and 18,8 tonnes/capita.

This calculation puts Sweden above the estimates made for Germany, USA and Japan, and in the same size as the Netherlands. There are several explanations for the differences. Differences can be explained by system boundaries, by data sources and by how the exports are treated.

For the fossil fuels, Sweden and Japan have similar per capita figures of about 3 tonnes/capita.

For the construction minerals Sweden has a high figure. This may be explained by what statistics have been available for the different studies. The so-called industrial statistics, which are primarily used for economic assessments, have system boundaries that cover most of the economic flows, but not necessarily the physical flows. In this study, raw material statistics was often taken from other sources than the industrial statistics.

For the renewable materials, Sweden's per capita input appears to be 5 tonnes higher than the other countries, which may be explained by the dominating forest industry. Also for food production the figures are higher than the USA, Germany and Japan. This may be due to the choice of statistic sources.

The system boundary chosen for the ores has a major impact on the results. The international comparison made it clear that earlier studies have had a boundary different to the one chosen in this study. The *concentrates* of metals have been considered direct flows in the international studies, while we have considered the *ores* as direct flows. We present re-calculated figures that can be compared to the international figures, but the main text of the report is still based on the definition of ores as direct flows. This can be recalculated in future work. Also recalculated, the ores will be more important for Sweden than for the other countries in the comparison, since mining is a major industry in Sweden.

The fact that Sweden is a small country with a relatively large export of raw materials such as forestry and ores is evident in the results. If we separate exports from domestic material consumption (DMC) the per capita figures decrease by about 5 tonnes per capita. This difference is important to be able to distinguish, in order to separate life style changes from exports of raw materials.

Different raw materials have been allocated on branches of industry by means of input-output analysis. Unfortunately, because of the aggregation of the monetary input-output table, ores and industrial minerals could not be separated. This problem, that the monetary tables could not single out such different industries, could not be solved in this project.

Similar input-output analyses were performed for air emissions and hazardous waste. The expected connections between carbon dioxide emissions from energy intensive mining and large material flows are seen.

Further studies are obviously needed in order to provide us with the tools for allocating physical flows over industries or commodities, with better precision. One of these tools will most likely be disaggregated monetary input/output tables.

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Appendix 1: The DMI account - detailed data, in 1000 tonnes

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Domestic production											
Non renewables											
Fossil fuels											
Solid	357	955	1,011	986	814	1,027	523	1,113	792	684	1,020
Liquid	4	2	3	3	3	1	0	5	3	0	0
Gaseous	0	0	0	0	0	0	0	0	0	0	0
	361	**957**	**1,014**	**989**	**817**	**1,028**	**523**	**1,118**	**795**	**684**	**1,020**
Ores											
Iron ore	22,474	22,042	23,907	21,222	20,962	21,234	20,605	22,149	23,682	23,766	24,018
Non-iron ores	18,634	17,599	18,259	18,566	20,634	22,165	22,333	22,801	24,226	24,917	23,895
	41,108	**39,641**	**42,166**	**39,788**	**41,596**	**43,399**	**42,938**	**44,950**	**47,908**	**48,683**	**47,913**
Industrial minerals											
Industrial minerals	3,651	4,076	4,266	4,982	4,727	4,453	4,106	4,916	5,145	5,062	5,529
Peat for agricultural use	230	233	236	238	236	270	275	320	317	325	361
	3,881	**4,309**	**4,502**	**5,220**	**4,963**	**4,723**	**4,381**	**5,236**	**5,462**	**5,387**	**5,890**
Construction minerals											
Sand and gravel	63,800	63,500	70,700	69,800	63,300	53,100	51,895	43,492	44,554	33,349	26,270
Crushed stone	18,400	20,900	23,400	25,100	24,900	22,600	25,962	28,592	32,348	30,714	28,988
Morain and other	3,400	3,600	4,700	5,100	4,500	5,800	7,800	10,400	10,300	6,300	6,300
Limestones for cement	3,271	3,651	3,821	4,540	4,402	4,352	4,116	4,520	4,989	4,798	4,516
Natural stones	200	200	200	210	240	120	126	136	160	182	155
Slab of stone	30	30	30	30	30	33	33	28	30	60	60
	89,101	**91,881**	**102,851**	**104,780**	**97,372**	**86,005**	**89,932**	**87,168**	**92,381**	**75,403**	**66,289**
Renewables											
Raw material for food production											
Fodder for beef	6,578	6,561	6,652	6,789	6,571	6,810	6,829	6,831	6,723	6,733	6,743
Fodder for pork	589	595	588	590	577	593	589	681	686	727	724
Fodder for eggproduction	283	285	290	283	246	253	246	237	242	253	246
Fodder for poultry	20	20	22	23	26	32	32	38	41	43	43
Lamb	5	5	5	5	4	4	4	4	3	4	3
Reindeer	3	3	3	3	3	3	3	2	2	2	1
Honey	3	3	5	2	2	2	2	2	2	1	1
Cereals	1,695	1,423	2,070	2,578	1,646	1,542	1,976	1,518	1,760	2,196	2,195
Peas										68	114
Potatoes	958	1,283	1,179	1,186	1,029	1,253	976	763	1,074	1,201	1,214
Sugar beet	1,699	2,439	2,654	2,776	1,628	2,136	2,535	2,350	2,479	2,430	2,639
Oil-yielding plant	296	293	421	422	288	284	314	195	196	143	133
Fruit and vegetables	178	178	232	232	232	252	252	252	261	261	261
	12,305	**13,087**	**14,121**	**14,889**	**12,251**	**13,164**	**13,759**	**12,874**	**13,469**	**14,062**	**14,318**
Wild berries and mushrooms	**70**	**70**	**70**	**32**	**32**	**32**	**32**	**32**	**32**	**32**	**32**
Hunting	**20**	**21**	**22**	**22**	**20**	**19**	**18**	**16**	**16**	**16**	**16**
Fishing (commercial)	**202**	**237**	**244**	**251**	**237**	**307**	**342**	**387**	**405**	**371**	**357**
Forestry											
logging	**45,189**	**46,457**	**48,172**	**47,352**	**46,010**	**47,799**	**48,321**	**50,036**	**56,226**	**50,484**	**54,138**

Appendix 1 (cont.)

	HS Code	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Imports												
Non-renewables												
Fossil fuels												
Solid		4,248	4,221	4,200	3,911	3,498	3,373	3,494	3,780	4,103	3,782	3,850
Liquid		22,358	21,712	21,866	22,761	22,367	23,957	23,712	24,833	23,892	25,903	25,568
Gaseous		724	*747*	*926*	*1,151*	*1,179*	*1,371*	*1,355*	*1,458*	*1,430*	*1,485*	*1,494*
		27,330	**26,680**	**26,991**	**27,823**	**27,044**	**28,700**	**28,560**	**30,072**	**29,425**	**31,170**	**30,912**
Ores												
Iron ore	2601	70	129	255	268	442	355	588	382	184	150	120
Iron&steel products	Chapter 72, 73	3,149	3,353	3,216	2,814	2,285	2,463	2,756	3,598	3,470	3,299	3,923
Vehicles	Ch. 87	917	966	963	780	635	599	513	732	713	730	855
Non-iron ores	Ch. 26 (excl 2601)	456	601	551	313	379	471	365	472	551	540	422
Non-iron&steel products	Ch. 74-83	438	480	477	476	490	462	484	635	600	570	623
White goods	Ch. 84	40	43	49	49	47	42	38	45	42	45	57
		5,071	**5,572**	**5,512**	**4,700**	**4,279**	**4,391**	**4,744**	**5,864**	**5,560**	**5,333**	**6,000**
Industrial minerals	Parts of Ch.25,68,69,70	**3641**	**3947**	**3800**	**3608**	**3100**	**2835**	**2833**	**3117**	**3343**	**3311**	**3745**
Construction minerals	Parts of Ch. 25,68,69	**5186**	**1636**	**1603**	**1788**	**1770**	**1410**	**1646**	**1238**	**1090**	**1237**	**943**
Renewables												
Raw material for food production												
Meat	Ch. 2	26	30	21	21	30	37	24	29	42	55	53
Fish	Ch. 3	56	55	60	58	59	64	65	83	97	117	124
Dairy produce	Ch. 4	24	25	25	35	45	48	44	49	43	52	63
Vegetables	Ch. 7	308	283	226	241	291	285	243	280	340	332	296
Fruits and nuts	Ch. 8	477	476	486	510	549	536	529	558	477	529	557
		890	**868**	**819**	**865**	**975**	**970**	**905**	**999**	**1,000**	**1,086**	**1,094**
Forestry												
Wood & articles of wood	Ch. 44	7,265	7,712	7,324	4,629	4,400	5,076	4,517	6,969	8,105	5,859	8,321
Pulp of wood	Ch. 47	270	315	367	470	492	704	744	832	939	773	835
Paper & paperboard	Ch. 48	357	400	417	466	454	482	507	620	580	629	675
		7,892	**8,427**	**8,108**	**5,566**	**5,346**	**6,262**	**5,768**	**8,421**	**9,624**	**7,261**	**9,831**
Exports												
Non-renewables												
Fossil fuels												
Solid		317	169	112	99	105	96	203	141	134	183	110
Liquid		7,298	6,425	7,766	8,151	7,648	9,341	9,238	8,592	9,106	8,588	9,484
Gaseous		44	*23*	*30*	*35*	*73*	*107*	*138*	*113*	*121*	*224*	*230*
		7,659	**6,617**	**7,908**	**8,285**	**7,826**	**9,544**	**9,579**	**8,846**	**9,361**	**8,995**	**9,824**
Ores												
Iron ore	2601	16,762	17,625	17,484	16,398	15,251	15,581	16,442	15,393	16,918	15,173	17,572
Iron & steel products	Ch. 72, 73	3,227	3,238	3,168	3,072	3,451	3,528	3,812	4,377	3,266	3,760	4,074
Vehicles	Ch. 87	468	775	723	723	679	728	770	971	992	933	1,012
Non-iron ores	Ch. 26 (exkl 2601)	595	492	479	515	506	498	599	536	491	443	475
Non-iron&steel products	Ch. 74-83	409	418	395	418	442	464	455	505	571	592	638
White goods	Ch. 84	52	56	52	51	50	55	58	67	78	68	83
		21,512	**22,605**	**22,300**	**21,176**	**20,379**	**20,853**	**22,134**	**21,849**	**22,316**	**20,969**	**23,853**
Industrial minerals	Parts of Ch.25,68,69,70	**1067**	**855**	**941**	**839**	**726**	**705**	**771**	**840**	**873**	**758**	**794**
Construction minerals	Parts of Ch. 25,68,69	**3195**	**3218**	**2868**	**3161**	**3446**	**3561**	**4041**	**5098**	**5224**	**6959**	**6041**
Renewables												
Raw material for food production												
Meat	Ch. 2	38	39	46	44	25	17	25	20	32	56	77
Fish	Ch. 3	50	58	69	76	78	57	39	46	110	208	186
Dairy produce	Ch. 4	61	43	62	88	52	28	37	25	55	48	74
Vegetables	Ch. 7	42	31	30	29	30	24	27	26	25	30	44
Fruits and nuts	Ch. 8	13	15	14	15	14	14	15	15	15	35	36
		203	**186**	**220**	**252**	**199**	**140**	**142**	**132**	**237**	**376**	**417**
Forestry												
Wood & articles of wood	Ch. 44	5,679	5,025	4,945	4,616	4,783	5,389	6,509	6,962	7,337	7,725	7,451
Pulp of wood	Ch. 47	3,239	3,314	3,103	2,909	2,979	2,931	3,001	3,017	2,746	2,856	3,091
Paper & paperboard	Ch. 48	6,448	6,770	6,859	6,910	6,893	7,116	7,552	8,282	7,996	7,971	8,725
		15,366	**15,109**	**14,907**	**14,434**	**14,655**	**15,436**	**17,062**	**18,261**	**18,079**	**18,552**	**19,267**

Appendix 2: Direct Material Input and Domestic Material Consumption, tonnes per capita, divided into Fossil fuels, Ores, Industrial minerals, Construction minerals, Raw material for food production and Forestry.

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Non-renewables											
Fossil fuels											
DMI per capita	3.4	3.3	3.3	3.3	3.2	3.4	3.4	3.5	3.4	3.6	3.5
DMC per capita	2.4	2.5	2.4	2.4	2.3	2.3	2.2	2.5	2.4	2.6	2.5
Ores											
DMI per capita	5.5	5.3	5.6	5.2	5.3	5.5	5.5	5.8	6.1	6.1	6.1
DMC per capita	2.9	2.7	3.0	2.7	2.9	3.1	2.9	3.3	3.5	3.7	3.4
Industrial minerals											
DMI per capita	0.9	1.0	1.0	1.0	0.9	0.9	0.8	0.9	1.0	1.0	1.1
DMC per capita	0.8	0.9	0.9	0.9	0.8	0.8	0.7	0.9	0.9	0.9	1.0
Construction minerals											
DMI per capita	11.2	11.1	12.2	12.4	11.5	10.1	10.5	10.0	10.6	8.7	7.6
DMC per capita	10.8	10.7	11.9	12.0	11.1	9.6	10.0	9.4	10.0	7.9	6.9
Renewables											
Raw material for food production											
DMI per capita	1.6	1.7	1.8	1.9	1.6	1.7	1.7	1.6	1.7	1.8	1.8
DMC per capita	1.6	1.7	1.8	1.8	1.5	1.7	1.7	1.6	1.7	1.7	1.7
Forestry											
DMI per capita	6.3	6.5	6.6	6.2	5.9	6.2	6.2	6.6	7.5	6.5	7.2
DMC per capita	4.5	4.7	4.9	4.5	4.2	4.4	4.2	4.6	5.4	4.4	5.1

Appendix 3: Direct Material Input and Domestic Material Consumption, tonnes per capita, Total and divided into Fossil fuels, Other non-renewables and Renewables

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Fossil fuels											
DMI per capita	3.4	3.3	3.3	3.3	3.2	3.4	3.4	3.5	3.4	3.6	3.5
DMC per capita	2.4	2.5	2.4	2.4	2.3	2.3	2.2	2.5	2.4	2.6	2.5
Other non-renewables											
DMI per capita	17.6	17.4	18.8	18.6	17.7	16.4	16.7	16.7	17.6	15.8	14.8
DMC per capita	14.5	14.2	15.8	15.7	14.9	13.5	13.7	13.6	14.4	12.5	11.3
Renewables											
DMI per capita	7.9	8.2	8.4	8.0	7.5	7.9	7.9	8.3	9.1	8.3	9.0
DMC per capita	6.1	6.4	6.6	6.3	5.8	6.1	5.9	6.2	7.1	6.1	6.8
Total											
DMI per capita	29	29	30	30	28	28	28	28	30	28	27
DMC per capita	23	23	25	24	23	22	22	22	24	21	21

Appendix 4: Direct Material Input and Domestic Material Consumption, thousand tonnes, divided into Fossil fuels, Ores, Industrial minerals, Construction minerals, Raw material for food production and Forestry.

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
DMI											
Fossil fuels	27,691	27,636	28,005	28,811	27,861	29,728	29,083	31,190	30,220	31,854	31,932
Ores	46,179	45,213	47,678	44,488	45,875	47,790	47,682	50,814	53,468	54,016	53,913
Industrial minerals	7,522	8,256	8,302	8,827	8,063	7,558	7,214	8,353	8,805	8,698	9,634
Construction minerals	94,286	93,517	104,454	106,568	99,143	87,415	91,578	88,406	93,471	76,640	67,232
Raw material for food production	13,488	14,283	15,276	16,103	13,515	14,491	15,056	14,307	14,991	15,567	15,817
Forestry	53,081	54,885	56,280	52,918	51,355	54,061	54,090	58,457	65,850	57,745	63,968
Total	**242,247**	**243,790**	**259,994**	**257,715**	**245,811**	**241,044**	**244,703**	**251,527**	**266,805**	**244,520**	**242,497**
DMC											
Fossil fuels	20,032	21,019	20,097	20,526	20,035	20,184	19,504	22,343	20,860	22,859	22,108
Ores	24,667	22,607	25,377	23,311	25,496	26,937	25,548	28,964	31,152	33,048	30,060
Industrial minerals	6,455	7,401	7,361	7,988	7,336	6,853	6,443	7,513	7,932	7,940	8,841
Construction minerals	91,092	90,299	101,586	103,407	95,697	83,854	87,537	83,308	88,247	69,681	61,191
Raw material for food production	13,284	14,098	15,056	15,852	13,316	14,351	14,914	14,176	14,753	15,190	15,400
Forestry	37,716	39,776	41,373	38,483	36,700	38,626	37,028	40,196	47,771	39,193	44,701
Total	**193,245**	**195,200**	**210,851**	**209,568**	**198,580**	**190,804**	**190,974**	**196,500**	**210,715**	**187,912**	**182,301**