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National Material Flow Analysis: Cuba.

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Abstract

Material Flow Accounting (MFA) is a resource accounting tool based on the concept of social metabolism. This national MFA Cuba investigates the overall structure and dynamics of the Cuban physical economy and its material flows (domestic extraction, imports and exports) between 1970 and 2003 in four main material categories (biomass, non-metallic minerals, metal ores and fossil fuels). The derived material flow indicators domestic extraction (DE), domestic material consumption (DMC), material intensity (MI), physical trade balance (PTB) and their material composition are examined. Further, the interrelationship of material use with economic growth and human development in Cuba between 1970 and 2003 is evaluated. Special attention is given to the structure of its energy system and the disaggregated material flows nickel and sugar cane.

Three phases are observed in the development of the physical economy in socio-economic and environmental terms, reflected in most economic and MFA-derived indicators: a period of growth (1970-1989), collapse (1989) and recovery (1990-2003). The structure of the Cuban physical economy is little diversified, specialized in the extraction and export of few raw materials, mainly sugar cane and nickel. Domestic extraction comprises mainly biomass (70%) and minerals (20%). Biomass accounts for 25% of the physical imports and 60%-90% of the physical exports between 1970 and 2003. The domestic primary energy supply is based on fossil fuel imports, mainly crude oil and oil products, comprising 70% of all physical imports. From a global perspective the ecological footprint and per capita energy consumption is relatively low.

Kurzbeschreibung

Die Materialflussanalyse (MFA) ist ein Ressourcenaggregations-Instrument, welches auf dem Prinzip des sozialen Metabolismus basiert. Diese nationale MFA-Studie untersucht die Struktur und Entwicklung der physischen Ökonomie und der Materialflüsse - natürliche Entnahme, Importe und Exporte - in Kuba zwischen 1970 und 2003 in vier Materialgruppen (Biomasse, Mineralien, Erze und fossile Energieträger). Die MFA-Indikatoren Materialentnahme *Domestic Extraction* (DE), Materialverbrauch *Domestic Material Consumption* (DMC), Materialintensität *Material Intensity* (MI) und die physische Handelsbilanz *Physical Trade Balance* (PTB) sowie ihre materielle Zusammensetzung werden betrachtet. Weiters wird der Zusammenhang zwischen Materialverbrauch, Wirtschaftswachstum und menschlicher Entwicklung in Kuba, zwischen 1970 und 2003, untersucht. Besonderes Augenmerk gilt dem Aufbau des Energiesektors und der Entwicklung der disaggregierten Materialflüsse Zuckerrohr und Nickel.

Hinsichtlich sozio-ökonomischer und ökologischer Parameter können drei Phasen in der Entwicklung der physischen Ökonomie unterschieden werden, welche sich auch in den meisten MFA-Indikatoren wiederfinden: eine Wachstumsperiode (1970-1989), Zusammenbruch (1989) und eine Erholungsphase (1990-2003). Die kubanische physische Ökonomie ist auf die Produktion einiger weniger Rohstoffe ausgerichtet, vor allem Zuckerrohr und Nickel. Die inländlische Materialentnahme (DE) umfasst hauptsächlich Biomasse (70%) und Mineralien (20%). Biomasse machte 25% der physischen Importe und 60% bis 90% der physischen Exporte zwischen 1970 und 2003 aus. In diesem Zeitraum wurde der Primärenergieverbrauch hauptsächlich durch Fossilenergieimporte gedeckt, besonders Öl und Ölprodukte, welche rund 70% aller physischen Importe ausmachten. Kubas ökologischer Fußabdruck und Pro-Kopf Energieverbrauch sind im internationalen Vergleich verhältnismäßig niedrig.

Preface

The small Caribbean island state Cuba, low-income nation and one of the last Socialist countries in the world, sets an example in ecological and social performance worldwide. According to a study published in *Ecological Economics* in 2008, the country meets both criteria for sustainable growth with an HDI greater than 0.8 and a footprint to bio-capacity ratio lower than 1 earth equivalent. Cuba is also leading in biotechnology, pharmaceutical industry, recycling, urban and organic farming, and biological pest control. Great attention is given to the investigation and integration of wastes and by-products generated in the sugar industry for renewable energy, feed and paper production.

Cuba follows its individual path of development under the conditions of economic and political isolation. Nevertheless, it has simultaneously achieved high human development together with economic growth. Cuba is a unique example combining economic development along social and environmental parameters, which encouraged me to investigate more profoundly the structure of its physical economy, material flows and sustainability indicators.
By using MFA, my aim was to allocate a resource management tool, providing comparable datasets and statistics for designing efficient resource management and improving economic performance regarding its material intensity. This national MFA is a contribution to further sustainable development in Cuba, to support and facilitate integrated economic planning and control resource consumption. I hope this study will serve to identify future needs and challenges that the Cuban economy has to face in a quickly changing global context.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

In a global environment where societies have become conscious of the limits of growth, framed by a given capacity of our planet to provide the resources required for economic activities and to deal with waste and residues resulting from economic activities, new concepts and strategies are needed. This process suggests a sustainable use of our resources according to the Brundtland-definition in order to allow for further long-term growth and prosperity for present and future generations (WCED, 1987).

The social metabolism approach allows to monitoring resource use in relation to economic growth and provides tools and indicators for measuring sustainability. Material flow accounting (MFA) contributes to effective resource management and can support environmentally sound policies and decision-making on a local, regional and national level (Bringezu et al., 1998). Due to a growing interest in the sustainable use of natural resources and resource efficiency in the past years, an increasing number of EU member states have integrated material flow accounting in their national statistical programs (Weisz et al., 2007). In the present study the concept of social metabolism was used in order to investigate the relationship of resource use and economic development and to provide new insights into the Cuban physical economy. Material flow accounting (MFA) offers a number of sustainability indicators, and consistent and comparable data for monitoring material use and associated environmental pressures. It allows for *integrated environmental and economic accounting* (Bringezu et al., 1998:8) and represents a useful complement to conventional national accounting systems.

A national MFA on Cuba was selected, because this country

- represents a relatively closed economic system that combines specific structural characteristics of a planned economy,
- shows a particular economic development in a changing global context (collapse of the former USSR) under the conditions of economic and political isolation (Torricelli and HelmsBurtons Act),
- employs alternative forms of resource use and energy production (e.g. use of sugar cane residues and by-products) and
- shows an interesting constellation of a high HDI and a relatively small ecological footprint along with medium economic growth.

This national MFA for Cuba was composed at the IFF Vienna, Institute for Social Ecology in the course of a master thesis supervised by Ao. Univ. Prof. Dr. Fridolin Krausmann. In this analysis, the overall structure and development of the Cuban physical economy will be investigated. The material flows nickel and sugar cane, and its energy system as three important aspects of the Cuban physical economy will be assessed in detail. Further, I will investigate the inter-linkage of domestic extraction and material consumption with economic growth and human development in Cuba between 1970 and 2003.

This economy-wide material flow account presents a quantitative estimate of material flows related to domestic extraction, import and export of raw materials in Cuba between 1970 and 2003. The derived material flow indicators domestic extraction (DE), domestic material consumption (DMC), physical trade balance (PTB), and material intensity (MI) will be evaluated. Next, the interrelation of material use with human development and economic growth will be investigated. Three different kinds of indicators are used to link material flows with social and economic development. The HDI is used as a welfare indicator measuring human development, GDP is used as an income indicator measuring economic performance and material flow indicators are used as environmental indicators for measuring the natural impacts of socio-economic activities. In order to establish a connection between material use, economic performance and human development the derived material flow indicators domestic extraction (DE), domestic material consumption (DMC) and material intensity (t/USD) are compared to the development of the gross domestic product (GDP, PPP USD/cap) and the human development index (HDI).

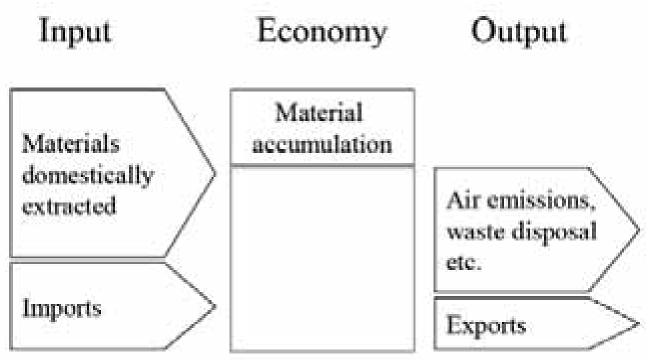
Section 5.3. provides a more detailed discussion of the flows of sugar cane, nickel and crude oil, which are key resources of the Cuban economy. Due to relatively high socio-economic importance and environmental pollution potential, the detailed material flows of sugar cane and nickel will be discussed against the economic-historical background from 1970 to 2003. Certain issues related to the extraction of these resources, e.g. land use, foreign direct investment and environmental contamination, will be addressed. The energy system of Cuba will be discussed regarding its dependency on oil imports and the increasing importance of domestic oil extraction. In the last part of this study MFA-derived indicators will be compared to the HDI and the ecological footprint, and discussed with the outcomes of a recent study on the global footprint and human development published by Moran et al. (2008) in *Ecological Economics*.

Concluding, I will summarize the most important driving factors for domestic extraction and domestic material consumption.

2. The Concept of MFA

The MFA concept is based on the principle of social metabolism and the first law of thermodynamics. Social metabolism is based on the idea that society, like an organism, uses and transforms material and energy in production and consumption processes, and interacts with its natural environment and other economies by exchanging material flows (export, import and domestic extraction of natural resources), emissions and wastes. In other words, economy-wide material flow accounting provides information on material entering and exiting a socio-economic system. It reveals the biophysical dimension of socio-economic activities by monitoring the *overall material inputs into a national economy, the material accumulation within the economic system and the material outputs to other economies or to the environment* (Weisz et al., 2006:3).

Fig. 1: Scope of Economy-Wide Material Flow Accounts



Source: Schandl et al. (2002)

The MFA concept also follows the first law of thermodynamics based on the conservation of matter. It states that the total amount of energy and matter is constant; it can neither be created nor can it be destroyed, only transformed (Georgescu-Roegen, 1999). Therefore in the material balance the amount of total material input equals output plus net accumulation (Fig.1). Material accumulation or net additions to stock describes all man-made physical assets, e.g. buildings or infrastructure.

The present MFA is a bulk flow analysis with focus on three material flows (imports, exports and domestic extraction). Physical data on these flows comes from both international and national statistical sources. This national MFA Cuba was compiled according to the methodological standards described in Eurostat (2001), Schandl et al. (2002) and Weisz et al. (2007). It is important to note that MFA standards were designed to fit the needs of economies of Western industrialized countries. In order to respond to country-specific issues of a tropical economy and to low data availability, some methodological adaptations and estimations had to be made, specified in section 3.

2.1. System Boundaries and Conventions

MFA refers to balancing accounts of raw materials in physical units (1,000 m.t.). According to MFA conventions in this analysis those solid, gaseous and liquid materials are accounted for which

- are measurable in metric tons,
- are extracted from the natural environment of the national economy (domestic extraction),
- are crossing the political (administrative) border of national territory (export/import),
- are subject to further socio-economic use.

In MFA, to account for material flows, system boundaries have to be drawn between socio-economic systems and between socio-economic systems and their natural environment. Animal livestock, for instance, is considered as part of the socio-economic system according to MFA conceptions. Thus, all grazed biomass, market feed and crop residues fed to livestock is accounted for, whereas the production of secondary products like meat, milk, cheese and yogurt is considered an internal flow and is not accounted for as domestic extraction. Live animals and animal products are only accounted for as imports and exports.

Basically, this MFA follows the guidelines described in Weisz et al. (2007). Domestic extraction, imports and exports comprise raw materials, semi-manufactured and manufactured goods are not accounted for. Only direct flows are considered; indirect or hidden flows associated with DE or trade flows are not accounted for. Inputs of air and water are not accounted for as well as outputs of wastes and emissions.

At this point it should be said that MFA is a biophysical accounting tool that focuses on mass flows irrespective of their chemical properties and their contamination potential. Therefore this methodology delivers purely quantitative results and mass indicators.

2.2. MFA Derived Indicators

This chapter provides a short overview of technical definitions of the most common material flow concepts and indicators used in this analysis. *Aggregated economy-wide material flow indicators allow monitoring the material use of national economies in a comparable, transparent and comprehensive way*. (Weisz et al., 2006:4) The use of two different denominators reveals different aspects of the physical economy. Population [t/cap/yr] and land area [t/ha] were chosen as denominators, because they pose a limiting factor to the use of natural resources.

2.2.1. Domestic Extraction (DE)

The aggregate flow DE covers the annual amount of raw materials (biomass, non-metallic minerals, metal ores and fossil energy carriers) extracted from the national territory in order to be used as material inputs to economic processing. (Weisz et al., 2006)

2.2.2. Imports

Physical imports comprise all import commodities that enter a socio-economic system. Import data usually refers to the form and mass weight of a good, as it is at the moment it crosses the administrative border. Unlike domestic extraction, trade data also includes durable goods, finished and semi-finished manufactured goods made from metal ores, non-metallic minerals and fossil energy carriers.

2.2.3. Exports

Exports are classified in the same way as imports. Physical exports also comprise finished and semi-finished products, and are reported at the net weight of a good when it crosses the political border of a national territory.

2.2.4. Domestic Material Consumption (DMC)

DMC = DE + Im - Ex

Domestic Material Consumption equals domestic extraction plus imports minus exports. DMC measures the total amount of materials that is directly used in an economy; it reveals how much material actually remains on the territory of a country (Eurostat, 2001). In this sense the DMC also indicates the *domestic waste potential* (Weisz et al., 2006). It is important to note that the term *consumption* as used in material flow accounting means *apparent consumption* in terms of domestic material input minus exports, not *final consumption* (Weisz et al., 2007).

2.2.5. Physical Trade Balance (PTB)

PTB = Imports – Exports

Physical trade balance equals physical imports minus physical exports. *The physical trade balance, thus, is defined reverse to the monetary trade balance (which is exports minus imports), taking into account the fact that in economies money and goods move in an opposite direction* (Weisz et al., 2007:94). Physical trade surplus indicates net import of materials, whereas physical trade deficit indicates net export.

2.2.6. Domestic Material Input (DMI)

DMI = DE + Imports

DMI equals domestic extraction plus imports. Domestic material input measures all materials of economic value that enter an economy for further socio-economic use, either in production or in consumption processes (Eurostat 2001, Weisz et al., 2007).

2.2.7. National Resource Dependency

The national resource dependency, also defined as DE/DMC ratio indicates *the dependence of the physical economy on its domestic raw material supply* (Weisz et al., 2007:95). In other words, the national resource dependency measures how much of the domestic material consumption could be covered by a country's own resources.

2.2.8. Material Intensity (MI)

Material intensity (DMC/GDP) measures material productivity in tons of material consumption per USD earned [t/USD]. In other words, material intensity expresses the employment of resources per unit of economic output. Its inverse, defined as resource efficiency (GDP/DMC) measures economic output per unit of material consumption [USD/t].

3. Methodology and Data Sources

The empirical base of this material flow analysis for Cuba is a data set covering domestic extraction, imports and exports of materials in time series for the period 1970 to 2003. Material accounts are structured in standard tables comprising 43 material categories, aggregated to 23 sub-categories aggregated in four main material categories (biomass, non-metallic minerals, metal ores and fossil energy carriers) on a 3-digit level (Fig. 2). Unless otherwise specified, data on foreign trade and the domestic extraction of biomass, construction and industrial minerals, fossil fuels and metal ores are based on data from the FAO, UN, USGS, IEA databases, several national statistical sources and international publications. Table 1 shows the most important data sources used in this analysis (Tab. 1). All data have been compiled according to the methodological standards described in Weisz et al. (2007). Additionally, Eurostat (2001) and Schandl et al. (2002) were used as methodological references. In this respect, the principal task was to create estimation models in order to respond to low data quality, and to develop methodological adaptations to meet the requirements of a tropical country.

Tab. 1: Overview of Most Important Data Sources

Material	Year	Source
Biomass	1970-2003	UN Food and Agricultural Organization Database (FAO 2005 CD-ROM Version)
Non- Metallic Minerals	1970-1989 1990-2003	UN Industrial Commodity Production Statistics Database United States Geological Survey Mineral Statistics
Metal Ores	1970-1989 1990-2003	UN Industrial Commodity Production Statistics Database United States Geological Survey Mineral Statistics
Fossil Energy Carriers	1970-2003	International Energy Statistics Database for Non-OECD Countries
Trade	**Year**	**Source**
Biomass	1970-2003	UN Food and Agricultural Organization Database
Fossil Energy Carriers	1970-2003	International Energy Statistics Database for Non-OECD Countries
Minerals & Metal Ores	1970-2003 2000-2002	Anuario Estadistico de Cuba 1989, 1998, 2005 UN Commodity Trade Statistics Database

Fig. 2: Structure of a Material Flow Account

- **A.1. Biomass**
  - A.1.1. Primary crops
    - A.1.1.1. Cereals
    - A.1.1.2. Roots, tubers
    - A.1.1.3. Sugar crops
    - A.1.1.4. Pulses
    - A.1.1.5. Nuts
    - A.1.1.6. Oil bearing crops
    - A.1.1.7. Vegetables
    - A.1.1.8. Fruits
    - A.1.1.9. Fibres
    - A.1.1.10. Other crops (Spices. Stimulant crops, Tobacco, Rubber and other crops)
  - A.1.2. Crop residues (used)
    - A.1.2.1. Straw
    - A.1.2.2. Other crop residues (sugar and fodder beet leaves, other)
  - A.1.3. Fodder crops incl. grassland harvest
    - A.1.3.1. Fodder crops
    - A.1.3.2. Biomass harvested from grassland
  - A.1.4. Grazed biomass
  - A.1.5. Wood
    - A.1.5.1. Timber (industrial roundwood)
    - A.1.5.2. Wood fuel and other extraction
  - A.1.6. Fish capture, crustaceans, molluscs and aquatic
  - A.1.7. Hunting and gathering
- **A.2. Metal ores (gross ores)**
  - A.2.1. Iron ores
  - A.2.2. Non-ferrous metal ores
    - A.2.2.1. Copper ores
    - A.2.2.2. Nickel ores
    - A.2.2.3. Lead ores
    - A.2.2.4. Zinc ores
    - A.2.2.5. Tin ores
    - A.2.2.6. Gold, silver, platinum and other precious metal ores
    - A.2.2.7. Bauxite and other aluminium ores
    - A.2.2.8. Uranium and thorium ores
    - A.2.2.9. Other metal ores
- **A.3. Non metalic minerals**
  - A.3.1. Ornamental or building stone
  - A.3.2. Limestone, gypsum, chalk, and dolomite
  - A.3.3. Slate
  - A.3.4. Gravel and sand
  - A.3.5. Clays and kaolin
  - A.3.6. Chemical and fertilizer minerals
  - A.3.7. Salt
  - A.3.8. Other mining and quarrying products n.e.c.
  - A.3.9. Excavated soil, only if used (e.g. for construction
- **A.4. Fossil energy carriers**
  - A.4.1. Brown coal incl. oil shale and tar sands
  - A.4.2. Hard coal
  - A.4.3. Petroleum
  - A.4.4. Natural gas
  - A.4.5. Peat

Source: Weisz et al. (2007)

3.1. Biomass

Biomass is the most fundamental material flow. It is essential for securing the domestic food supply of the entire population, and for providing industrial raw materials and energy carriers, e.g. fibres, wood and chemical compounds (Weisz et. al., 2007). In the same time biomass production is highly dependent on natural and climatic conditions. The economic value of biomass ranges from very low (less than EUR 10 per ton, e.g. crop residues) to medium high (e.g. spices, stimulants and fish); the vast majority of biomass comprises raw materials with low economic value (EUR 10-100 per ton, e.g. cereals, roundwood). The extraction of biomass is related to considerable environmental pressures, e.g. deforestation, soil erosion, water pollution and biodiversity loss (Weisz et al., 2007).

3.1.1. Data Sources

Both, national and international agricultural statistics have been used. The FAO database reports the production of altogether 160 different sorts of crops worldwide in time series starting from 1961. Most biomass data for Cuba has been drawn from the FAOSTAT CD-ROM edition published in 2005 (CD 1+2) also available online at www.fao.org/waicent/portal/statistics_en.asp. Data on fish catch comes from the FISHSTAT database, and data on the production of market feed comes from the FAO commodity balance sheets. In general, biomass data are accurate and consistent, and were cross-checked with the Handbook of Historical Statistics (1982) as well as with several official national statistics published in the Anuario Estadistico de Cuba (editions of 1989, 1998 and 2005). No serious deviations between national and international sources have been identified. Since there are no international data on used crop residues and grazed biomass available, these material flows need to be estimated.

3.1.2. Method of Calculation

3.1.2.1. Primary Crops

Primary crops comprise all primary crop harvest originating from agricultural activity. The MFA balance distinguishes primary crops according to cereals, roots and tubers, pulses, nuts, fibres, fruit, vegetables, oil-bearing crops and other crops (Fig. 2). The production of most primary crops is accounted for in fresh weight at harvest time (15-95% moisture content), only hay, grazed biomass, crop residues and fodder crops are standardized in air dry weight (15% m.c.).

3.1.2.2. Crop Residues

Crop residues represent a relatively large biomass flow. Some fraction of the crop residues produced is subject to further socio-economic use and therefore needs to be accounted for in the MFA. Crop residues such as straw and leaves are used for bedding, feed or construction, for energy production, or can simply be ploughed into the ground to fertilize the soil. In order to estimate the share of used crop residues of the total crop harvest production, a set of standardized indices is used (Tab. 2).

Tab. 2: Crop Factors

Commodity	Share of Residues of Total Biomass Production**	Share of Used Residues	Share of Residues Used as Feed	Moisture Content
Maize	65%	90%	66%	15%
Rice, Paddy	60%	90%	66%	15%
Sorghum	65%	90%	66%	15%
Bananas	20%	90%	66%	15%
Beans, Dry	30%	50%	66%	15%
Cassava	50%	75%	66%	15%
Potatoes	50%	75%	66%	15%
Sweet Potatoes	50%	75%	66%	15%
Yams	50%	75%	66%	15%
Yautia (Cocoyam)	50%	75%	66%	15%
Sugar Cane	42%*	90%	66%	83%

Source: Wirsenius (2000)

*Valdes Delgado et al. (2001)

** calculation based on the share of primary crops of the total biomass production.

The fraction of available residues is based on the share of crops of the total primary crop harvest. It is assumed that available residues amount to 20% to 65% of the total primary crop harvest. The mass of available crop residues is calculated according to the following formula.

Available crop residues [t (as is weight)] = primary crop harvest [t (as is weight)]/ share of crops (%) * [1-share of crops (%)]

Source: Weisz et al. (2007)

The share of used residues of the available residues is required to estimate the amount of used crop residues. It varies across crops, countries and time. The share assumed for used crop residues in Cuba lies between 50% and 90%. The amount of used crop residues is calculated according to the following formula.

Used crop-residues [t (as is weight)] = available crop-residues [t (as is weight)] * share of used residues (%)

Source: Weisz et al. (2007)

3.1.2.3. Grazed Biomass

(a) Estimate based on Feed Demand and Feed Supply

Because grazed biomass represents a relatively large flow, but is not reported in FAO agricultural statistics, a demand driven feed balance is used to identify the “grazing gap”. Grazed biomass constitutes the difference between the calculated feed demand and the supply of market feed, fodder crops and crop residues used as feed.

Grazed Biomass=Feed Demand [t (DM at 15% m.c.)] - Market Feed [t (DM at 15% m.c.)] - Residues used as Feed [t (DM at 15% m.c.)] - Bagasse Used for Feed [t (DM at 50% m.c.)]

Source: Weisz et al. (2007)

There are no significant amounts of fodder crops produced in Cuba, instead sugar cane residues and by-products are commonly used for animal feed. The following approach assumes a tropical animal feeding system. It takes into account the use of bagasse for cattle feed.

3.1.2.3.1. Feed Demand

Animal livestock is divided into grazers (horses, cattle, mules, asses, sheep and goats) and non-grazers (pigs and poultry). Data on livestock are used to quantify the feed demand and to estimate the amount of grazed biomass. Data on animal livestock and the production of secondary animal products (meat, egg and milk production) come from the FAO database which was compiled according to the following steps. A direct relationship is assumed between animal efficiency and feed requirement. The actual feed demand is calculated based on egg, meat and milk production, using specific regional efficiency and intake factors for accounting the annual intake of market feed and grazed biomass. All factors are based on Wirsenius (2000) and Krausmann et al. (2008b).

Cattle Feed Demand

The feed demand of cattle was calculated as linear function based on milk yield (A) and carcass weight (B), using specific daily intake factors.

Feed Demand A [kg DM/head and day] = 0.00155*milk yield + 4.8375
Feed Demand B [kg DM/head and day] = 0.036361*carcass weight + 1.702006

Source: Calculation based on Wirsenius (2000), Krausmann et al. (2008b)

The average of feed demand A and feed demand B was calculated. Finally, the daily cattle feed demand [kg DM/head and day] was used to calculate the annual feed requirement [1,000 m.t. DM / cattle stock and year].

Annual feed intake cattle [1,000 m.t. DM/livestock and year] = (Livestock[heads]*Average Feed Demand [kg DM/head and day] *365)/1,000,000

Source: Calculation based on Wirsenius (2000), Krausmann et al. (2008b)

Pig Feed Demand

The feed requirement for pigs was estimated 9 kg feed (dry matter) for the production of one kg of pork for Latin America and the Caribbean. This results in a per capita feed demand for pigs of 1.3 kg DM/ head and year. In order to estimate the annual feed intake of pigs the following formula was used.

Feed Demand Pigs [1,000 m.t. DM/ livestock and year] = Pig Meat * 9

Source: Calculation based on Wirsenius (2000), Krausmann et al. (2008b)

Poultry Feed Demand

The feed demand of poultry was estimated based on meat and egg production, assuming a specific regional efficiency factor of 3 kg feed/kg hen eggs or 3.6 kg feed/kg chicken meat respectively. The poultry feed demand was calculated using the following formula.

Feed Demand Poultry A [1,000 m.t. DM/ year] = Chicken Meat * 3.6
Feed Demand Poultry B [1,000 m.t. DM/ year] = Hen Eggs * 3.0

Source: Calculation based on Wirsenius (2000), Krausmann et al. (2008b)

Finally feed demand A and B were added.

Feed Demand Other Animals

The feed demand of horses, goats, sheep, mules and asses was calculated using per-head-and-day factors for dry matter feed intake (Tab. 3).

Feed Demand Other Animals [1,000 m.t. DM/ year] =Livestock [heads]* 365 * Factor [kg DM/head and day] /1,000,000

Source: Calculation based on Wirsenius (2000), Krausmann et al. (2008b)

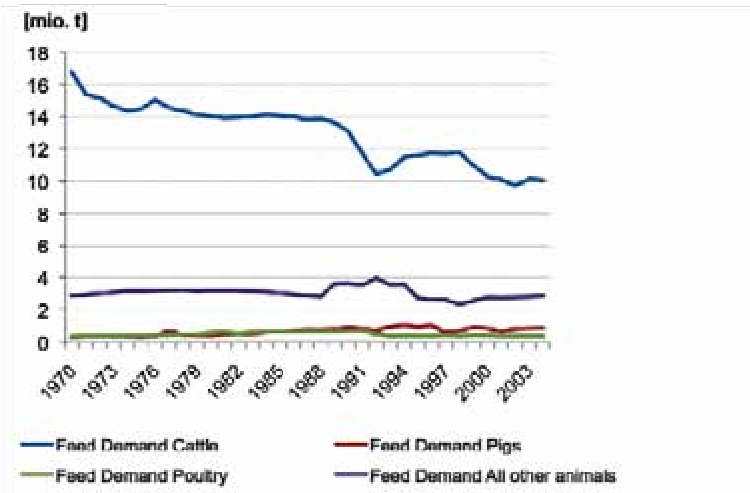
Tab. 3: Feed Intake Per Head and Day

Feed Intake	**[kg DM/head and day]**
Sheep	1
Goats	1
Horses	10
Asses	6
Mules	6

Source: Factors based on Wirsenius (2000), Krausmann et al. (2008b)

Figure 3 shows the feed demand of animal livestock [mio. t DM/yr] between 1970 and 2003. The calculated annual feed demand for all animals varies from 14 million tons to over 20 million tons dry matter. Cattle feed demand dominates, accounting for 75%, followed by all other grazers, accounting for 18% of the total feed demand. Pigs and poultry are of minor importance, accounting for 7% of the total feed demand. The overall feed demand declined in the 1990s, mainly due to a reduction of cattle livestock.

Fig. 3: Feed Demand Livestock



Source: Own calculation based on FAO (2004) and Wirsenius (2000)

3.1.2.3.2. Feed Supply

In this analysis I assume a tropical animal feeding system including sugar cane residues and by-products (Perez, 1992 and Quiroz et al., 1997). The following approach embraces the typical diet under tropical conditions considering the use of sugar cane and residues for animal feeding.

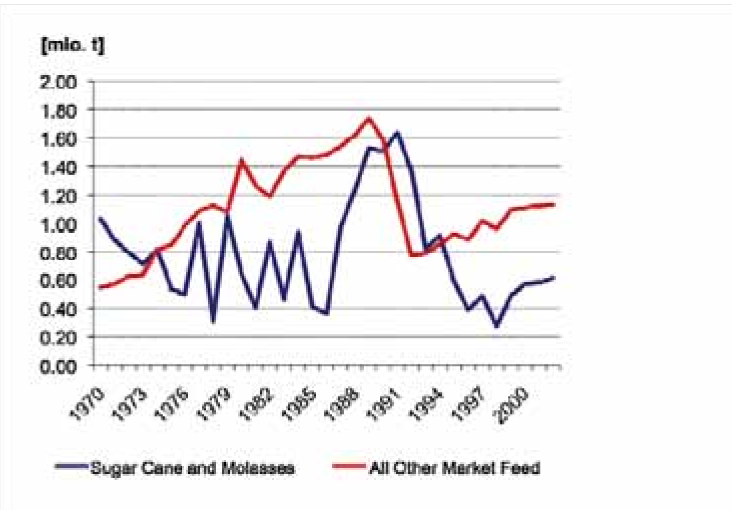
The typical diet of non-grazers consists of market feed, including mainly sugar cane and molasses. Poultry get market feed, mainly cereals and more recently dried cane leaves mixed with molasses at 70% “B” molasses and 30% dried sugar cane leaf meal (Preston, 1995). Pigs get market feed, mainly molasses, syrups and concentrated juice, cassava, sweet potato and banana (Perez, 1992). Despite crop residues and reject food, in Cuba in particular industrial and household organic waste are most likely to be reused as pig feed (Preston, 1995). Household and organic waste was, however, not taken into account in this analysis.

The typical diet of grazers consists of residual market feed, grazed biomass and fibrous sugar crop residues, e.g. cane tops, green and dry leaves, pressed stalk and chopped whole and derinded sugar cane (Preston, 1995). In Cuba in particular the *bagacillo* treated with sodium hydroxide (Preston, 1995), some fraction of pith (Valdes Delgado et. al, 2001) and other sugar by-products like filter cake, wastes and effluents are used for cattle feeding (Almazan et al.,1998).

Market Feed

Data for market feed comes from the FAO commodity balances. A considerable share of the available market feed is made up by sugar cane and molasses, accounting for an average of 40% of total market feed distributed in Cuba between 1970 and 2003 (Fig. 4).

Fig. 4: Sugar and Non-Sugar Market Feed



Source: calculation based on FAO (2004)

Market feed is accounted for in air dry weight (15% m.c.). The amount of market feed fed to grazers was calculated using the following formula.

Market Feed Available for Grazers = Feed Demand Pigs and Poultry [1,000 m.t. DM/ year] – Total Market Feed [1,000 m.t. DM]

Source: Weisz et al. (2007)

Residues Used for Feed

About 66% of all used residues are further used for feed. This information is relevant to establish the feed balance and to estimate the amount of grazed biomass. The amount of crop residues used for feed was calculated using the following approach.

Used crop residues for feed [1,000 m.t. GM] = Used crop-residues [1,000 m.t. GM] * 0.66

Source: Weisz et al. (2007), Krausmann et al. (2008b)

All used crop residues for feed are converted into air dry weight (15% m.c.). The moisture content varies among different species and needs to be considered. Sugar cane has a water content of 83%, whereas most other crops show 15% moisture content (see Tab. 2)

Used crop residues for feed at air dry weight [1,000 m.t DM] = Used crop residues for feed at fresh weight [1,000 m.t GM]* 0.15

Source: Weisz et al. (2007), Krausmann et al. (2008b)

Bagasse Used For Feed

It is assumed that bagasse accounts for 28% of the total sugar cane extraction.

Bagasse produced [1,000 m.t. GM (83% m.c)] = { (Sugar Cane Extraction GM [1,000 m.t. (83% m.c)] – Market feed [1,000 m.t. GM (83% m.c)] }* 0.28

Source: calculation based on Almazan et al. (1998)

Approximately 10% of bagasse produced is used as cattle feed.

Bagasse used for feed [1,000 m.t. GM (83% m.c)] = Bagasse produced [1,000 m.t. GM (83% m.c)] * 0.1

Source: calculation based on Valdes Delgado et al. (2001)

Bagasse used for feed is accounted for at 50% moisture content, according to the following formula.

Bagasse Used for Feed at air dry weight [1,000 m.t. DM (50% m.c)]= Bagasse Used for Feed [1,000 m.t. GM (83% m.c)] * 0.5

Source: calculation based on Valdes Delgado et al. (2001)

According to this calculation, the amount of bagasse used for feed decreased from 1.15 million tons dry matter (50% m.c.) or 1.15 t/cap/yr in 1970 to 0.32 million tons dry matter (50% m.c.) or 0.04 t/cap/yr in 2003. The amounts of fed sugar cane, bagasse, molasses and sugar residues appear realistic. These results match our presumption that in Cuba some 60% of the combined pig and grazer feed demand (Almazan et al.,1998) or 24-35% of the cattle feed demand respectively (Quiroz et al., 1997), are covered by sugar cane and its by-products.

* * *

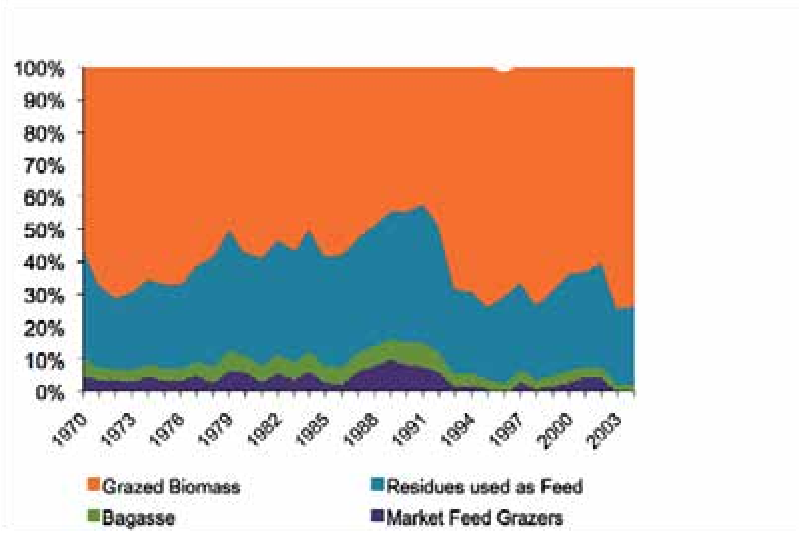
Finally, the feed balance is established (Fig. 5). All components need to be filled into the grazing balance in order to estimate the amount of grazed biomass:

Grazed Biomass=Feed Demand [t (DM at 15% m.c.)] - Market Feed [t (DM at 15% m.c.)] - Residues used as Feed [t (DM at 15% m.c.)] - Bagasse Used for Feed [t (DM at 50% m.c.)]

Source: based on Weisz et al. (2007), Krausmann et al. (2008b)

The grazers feed balance shows the amounts of grazed biomass, market feed, bagasse and residues used to cover the grazers´ feed demand. The major share of the feed balance is covered by grazed biomass, ranging from 40% to 70%. Residues used for feed account for 30%, residual market feed and bagasse altogether make up 10% of the grazers feed balance. Grazing declines during the economic crisis between 1989 and 1993, mainly as a consequence of the reduced cattle stock and gains importance in the mid 1990s. The use of residues for feed declines in the course of the 1990s according to the declining sugar cane production.

Fig. 5: Feed Balance Grazers



Source: Own calculation

(b) Estimate based on Land Use

The outcomes of method (a) were crosschecked with a grazing model based on the available pasture area. The average yield of usual fodder crops ranges, depending on land use and pasture, from 0.5 to 7.0 t/ha [15% m.c.] (Weisz et al., 2007). The yield of grazable biomass for Cuba was assumed 5 t/ha. A relatively high yield was chosen based on the assumption that pasture farming systems traditionally are quite common in Central America (Preston, 1995). Grazing model (b) based on the available pasture area was calculated using the following formula.

Grazed Biomass=Available Pasture Area (1,000 ha)*Yield (5t/ha)

Source: based on Weisz et al. (2007)

The outcomes of grazing model (a) match the results of grazing model (b). The amount of grazed biomass based on the feed demand on average is by 10% lower than the calculated amount of grazed biomass based on the available pasture area.

3.1.2.4. Fish Capture

Data on fish catch was taken from the FISHSTAT database. According to MFA conventions, only fish capture from open and fresh seawater systems is accounted for, whereas fish production from aquaculture is not considered natural extraction.

3.1.2.5. Wood Extraction

This category comprises industrial roundwood used in industrial processes (e.g. timber, paper), and fuel wood mainly used for energy production. The FAOSTAT database reports forestry data in terms of volume rather than weight. Standard factors, given in Table 4 are used to convert volume [m^3] into weight [m.t. DM (15% m.c.)] (Tab. 4).

Tab. 4: Wood Conversion Factors

Wood	Factor
Coniferous	0.52
Non-Coniferous	0.68

Source: Weisz et al. (2007)

MFA only accounts for biomass removed from forests for further socio-economic use. Branches, root-stocks and other unused biomass from woods are not included into the MFA balance. The wood bark, in contrast, is not reported by FAO agricultural statistics. Since wood bark is subject to further socio-economic use, an extension factor was used to correct the wood balance. The fraction of used bark is assumed 10% of the total stem wood (Weisz et al., 2007).

Wood removals incl. bark [t at 15% m.c.] = wood removals under bark [t at 15% m.c.]* 1.1

Source: Weisz et al. (2007)

Charcoal is still a relevant source of energy in Cuba. To account for wood used in charcoal production, the relation of wood used in charcoal production was assumed 3:1 in terms of volume.

3.2. Non-Metallic Minerals

The MFA questionnaire distinguishes between non-metallic industrial minerals and construction minerals, in practice some minerals are used for both industrial and construction purposes. Quantitatively construction minerals represent a relatively large flow of the domestic extraction of minerals and outweight industrial minerals by far. Construction minerals comprise sand, gravel, crushed stone and limestone. Most important industrial minerals produced in Cuba are gypsum and salt, and smaller quantities of marble, feldspar, iron pyrites, bentonite, kaolin and clays.

The vast majority of minerals comprise bulk raw materials with low economic value (less than EUR 100 per ton), e.g. washed sand, gravel, crushed stone. Industrial and construction minerals are used for a broad range of uses, e.g. inorganic chemicals, ceramics or table salt (Weisz et al., 2007).

3.2.1. Data Sources

Data on the extraction of industrial and construction minerals between 1970 and 1990 is taken from the United Nation Industrial Commodity Production Statistics Database www.unstats.un.org/unsd/industry/default.asp. Most data after 1990 comes from USGS sources http://minerals.usgs.gov/minerals/pubs/country/latin.html#cu, unless otherwise specified below. USGS mineral fact sheets for Cuba are available online for the years 1994, 1996, 2000 and 2004. An overview on data sources used to estimate the use of construction minerals (see section 3.2.2) is provided in table 5.

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Tab. 5: Data Sources Used to Calculate Construction Minerals

Material	Year	Source
Sand and Gravel	1970-1978	Schroeder (1982) A Handbook of Historical Statistics
	1970-1989	UN Industrial Commodity Production Statistics Database
Cement	1970-1978	Schroeder (1982) A Handbook of Historical Statistics
	1989-1993	Babun (1997) Cuba´s Cement Industry
	1980, 1983-1989	Oficina Nacional de Estadistica: Anuario Estadistico de Cuba 1989, 1998, 2005
GDP Construction	1970-2003	UN National Accounts Main Aggregates Database
Road Network	1971-1975	Schroeder (1982) A Handbook of Historical Statistics
	1989	IRS (1994) World Road Statistics
	1990-1999	World Bank (2007) World Development Indicators Database

Combining data from two or more databases requires great care. Due to different terminology and classification codes, breaks and double counts can appear that need to be removed. Limestone extraction for instance broke down in 1990 due to different terminology. While the United Nation Industrial Commodity Production Statistics Database reports limestone as “limestone & calcerous stone”, the USGS database reports the production of “lime” since 1990. The production of “sand, silica and quartz”, accounted for as “silica sand” by USGS statistics, shows a sudden rise in 1990. However, the final values for these construction minerals are based on an estimation model, specified in section 3.2.2.2.

In order to convert volume (m^3) into weight (m.t.) specific gravity factors recommended in Weisz et al. (2007) are used (Tab. 6).

Tab. 6: Mineral Conversion Factors

Item	Factor
Sand, dry	0.001602
Marble	0.002563
Gravel, dry	0.001682

Source: Weisz et al. (2007)

3.2.2. Method of Calculation

3.2.2.1. Industrial Minerals

Among the most important industrial minerals extracted in Cuba are gypsum and salt (>100,000 t/yr), and smaller amounts of marble, feldspar, iron pyrites, bentonite, kaolin and clays (< 50,000 t/yr). "Kaolin", reported as "kaolin clay" by the USGS shows some discontinuities after 1990. A crosscheck with national statistics suggests a real decline in the production of kaolin between 1990 and 1994. The production of marble, bentonite, magnesite and clays (total production) after 1989 is not reported at all by USGS statistics. That is tolerable, because in terms of weight, these commodities make up only a minor part of the total mineral flow.

3.2.2.2. Construction Minerals

Construction minerals usually represent a relatively large flow in material flow accounting, nevertheless they are likely to be neglected and/or under-represented by most common mineral statistics. Sand and gravel are cheap, abundant and easily accessible bulk materials and receive only little attention in official mineral reports and statistics.

In order to cross-check data on limestone, sand and gravel extraction reported in statistics, an estimation model was used based on data on cement production and road construction. It takes into account the input of limestone in cement production, and the amount of sand and gravel used for concrete and road construction derived from data on cement production and the development of the total road network. Finally, the calculated amounts of sand and gravel were added and compared to the original data reported by mineral statistics. The higher figures were used in this MFA.

Limestone

The input of limestone in cement production was rated 1.19 tons limestone to make 1 ton of cement (Tab. 7).

Limestone for Cement[t] = Cement [t] * 1.19

Source: Weisz et al. 2007

Tab. 7: Limestone Input in Cement Production

Commodity	Input[t]/Cement [t]
Limestone	1.19

Source: Weisz et al. 2007

Sand, Gravel and Crushed Stone

Sand and gravel are broadly used in structural engineering, mainly buildings and concrete, and civil engineering, mainly roads (Weisz et al., 2007). The following procedure takes into account the two main uses of sand and gravel as inputs for the production of concrete (Tab. 8) and as different layers in road construction (Tab. 9).

Sand for Cement[t] = Cement [t] * 2.4

Gravel for Cement[t] = Cement [t] * 3.7

Source: Weisz et al. 2007

Tab. 8: Sand and Gravel Input in Concrete Production

Construction Mineral	Input[t]/Cement [t]
Gravel and Crushed Stone	3.7
Sand	2.4

Source: Krausmann (2007) personal communication, Weisz et al. (2007)

Sand and gravel are also used as layers in road construction (measured by the length of newly built road per year) as well as for maintenance and upgrading of the total road network. The inputs of sand and gravel in road construction, upgrading and maintenance were calculated as follows using the factors below (Tab. 9).

Data on the Cuban road network is quite accurate and comes from the Handbook of Historical Statistics (1971-1975), World Road Statistics (1989) and the World Development Indicators Database (1990-1999). The total road network reported by the International Road Society for 1997 amounts to the double of that reported in 1996. Therefore, from 1996, an average growth rate was assumed (500 km/yr) in order to estimate the length of newly built road. The input of sand and gravel was rated 5 t/km.

Road upgrading refers to qualitative amendments and infrastructural improvements of the existing road network. The length of upgraded roads (km/yr) was assumed to amount to the double of newly built roads. The input of sand and gravel in the upgrading of roads was rated 2.8 t/km. Maintenance involves corrections and reparation in order to sustain and maintain roads in good working order. The input of sand and gravel in maintenance was rated 0.1 in the existing road network.

Sand and Gravel for Newly Built Road [t] = Newly Built Road [km/yr] * 5.0

Sand and Gravel for Maintenance [t] = Existing Road Network [km] * 0.1

Sand and Gravel for Upgrading [t] = Newly Built Road [km/yr] * 5.6

Source: Krausmann (2007) personal communication, Weisz et al. (2007)

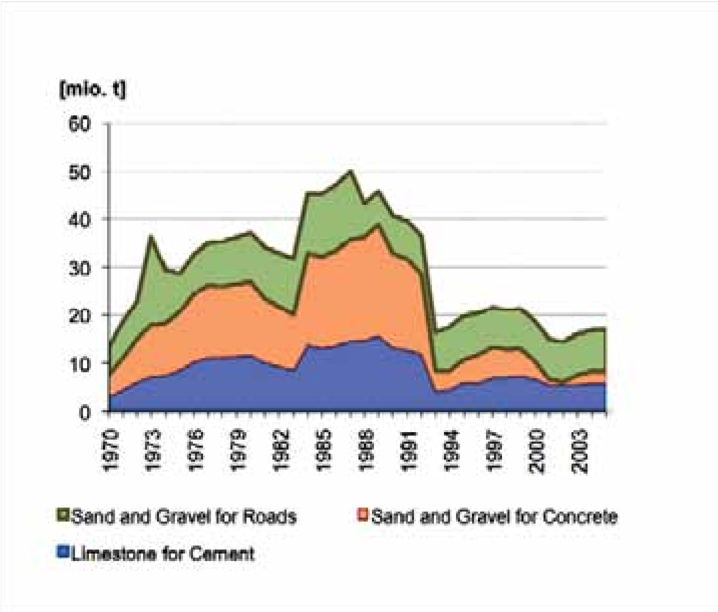
Tab. 9: Sand and Gravel Input in Upgrading, Maintenance and Road Construction

Construction Mineral	**Input[t]/Newly Built Road [km]**
Sand and Gravel for Maintenance	0.1
Sand and Gravel for Newly Built Road	5.0
Sand and Gravel for Upgrading	2.8

Source: Krausmann (2007) personal communication, Weisz et al. (2007)

Figure 6 shows the estimate of the total amount of used construction minerals in Cuba. Construction minerals are dominated by sand and gravel. Sand and gravel exceed the production of limestone by factor 2. The production of all construction minerals declines sharply in the early nineties.

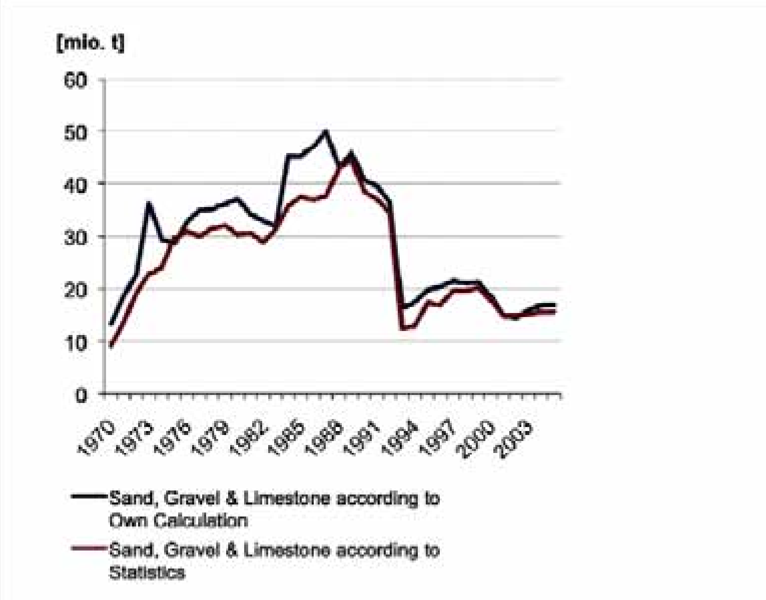
Fig. 6: Estimated Use of Construction Minerals



Source: Own calculation

Estimated figures for limestone, sand and gravel for cement and concrete production, and sand and gravel for road construction were added and compared with official figures for limestone, sand and gravel reported in national and international statistics. The original construction mineral data and the estimated construction mineral extraction match very well (Fig. 7). The higher figures were selected as data for the domestic extraction of limestone, sand and gravel.

Fig. 7: Inputs of Sand, Gravel and Limestone compared to Original Figures



Source: Own calculation based on the United Nations Industial Commodity Production Statistics Database (2004), USGS (2006) and Babun (2004)

For limestone extraction the original datasets were used as reported by statistics. Missing data for limestone was reconstructed along the cement production curve.

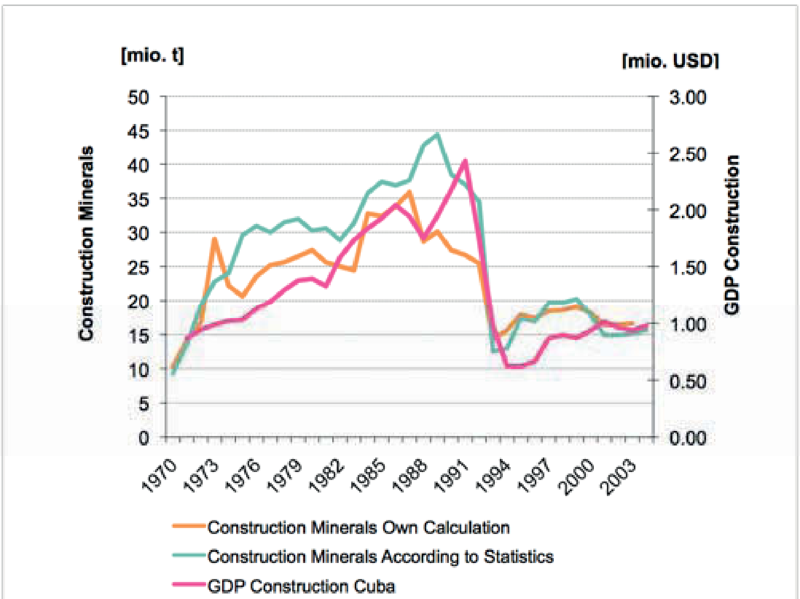
For sand and gravel extraction, the above described estimation approach was chosen considering the amount of sand and gravel in concrete and road production, because those outcomes appeared even more realistic due to higher values.

3.2.2.3. Construction Minerals and Economic Growth

From another angle, the mass inputs of construction minerals in cement production and road construction were crosschecked with the GDP of the construction sector. In MFA, it is generally assumed that construction minerals show a high volatility with economic growth based on the assumption that accelerated economic growth often results in enhanced construction activities and investments in physical infrastructure (Weisz et al., 2006).

Figure 8 illustrates the development of construction mineral extraction in relation to economic growth in the construction sector. It is interesting to note that the estimated outcomes based on the outlined assumptions show a strong correlation with the original mineral data (Fig. 8). That displays high data quality of the original datasets reported by national statistics on the one hand and proves the interrelation of construction minerals extraction, and economic growth and on the other.

Fig. 8: Construction Minerals and GDP



Source: Own calculation based on the United Nations Industial Commodity Production Statistics Database (2004), USGS (2006) and Babun (2004)

3.3. Metal Ores

In terms of weight, metal ores represent a relatively small flow. Metal ores, especially nickel and cobalt are strategically important commodities for the Cuban economy due to their relatively high socio-economic value. Other metal ores produced in Cuba are copper, chromium and small amounts of gold. Metal ores are required for a wide range of uses, e.g. construction, vehicles, machinery and household appliances. The extraction of metal ores is often associated with polluting and destructive processes related to mining and quarrying activities, e.g. ecosystems destruction, sealing of land, toxic waste and emissions (Weisz et al., 2007).

3.3.1. Data Sources

In general, data for metal ores from 1970 to 1989 was taken from the UN Industrial Commodity Production Statistics Database. Data on the production of metal ores for the later years were downloaded from the same USGS source like minerals available online http://minerals.usgs.gov/minerals/pubs/country/latin.html#cu.

3.3.2. Method of Calculation

Mineral mining involves the mobilization of huge amounts of materials (Weisz et al., 2007). Therefore material flow accounts follow a *run-of-mine* concept focusing on the production of gross ores. Gross ores reflect the total amount of extracted, metal containing material that undergoes further socio-economic processing. Overburden and interburden, material removed and deposited in order to reach ore containing minerals, is considered unused extraction and is not accounted for in this study.

3.3.2.1. Gross Ore

Gross ore values were re-calculated by using appropriate conversion factors, based on individual net-gross-ore ratios. Net ore data (metal concentrates) was used extended by individual factors, rather than gross ore data reported by the USGS. The calculated figures were compared to the reported gross ore data. The higher figures were chosen for the extraction of metal gross ores and crosschecked with metal contents recommended in literature, USGS and national statistical sources.

Gross ore of copper, chromium and nickel were calculated on the base of concentrate-gross-ore ratio (Tab. 10). The gross ore values of iron ore refer to original gross ore data reported in the United Nations Commodity Statistics Database. In order to figure out the quantities of cobalt obtained from nickel extraction, the shares of nickel and cobalt (96% Ni, 4% Co) were applied to the nickel gross ore values. Finally the calculated cobalt amounts were used instead of the reported figures on cobalt production.

Factor Concentrate-Gross Ore = 1/net-gross ore ratio [%]*gross weight [t]

Source: Eisenmenger (2007), personal communication

Tab. 10: Concentrate-Gross Ore Ratio and Corresponding Factors

Metal Ore	Metal Content	Concentrate-Gross Ore Factor
Nickel	0.93%	107.04
Chromium	23.95%	4.18
Copper	1.25%	80.16
Cobalt	0.98%	102.03
Gold	1.5 g Au/m.t.	666,666.67

Source: Own calculation based on USGS (2006)

3.4. Fossil Fuels

Fossil energy carriers are bulk raw materials of low economic value (less than EUR 100 per ton), used for energy production and as industrial raw materials, e.g. for the production of organic chemical compounds and synthetic materials or fibres (Weisz et al., 2007). The combustion of fossil fuels contributes to air pollution and global warming. Domestic extraction of fossil energy carriers is quite low in Cuba. It comprises small amounts of crude oil and associated gas.

3.4.1. Data Sources

Data on the production of fossil energy carriers was compiled from the Energy Statistics and Balances of NON-OECD Countries published by the IEA (2002). The IEA database provides information on the production and trade of fossil energy carriers and derived products from 1971 to 2001. Fossil fuel data for 2002 and 2003 was updated based on a trend development.

3.4.2. Method of Calculation

In order to convert data for natural gas given in upper heating value (MJ/kg) into weight (m.t.) a specific factor for calorific value was used, provided by IEA (2002) (Tab. 11).

Tab. 11: Natural Gas Density

Commodity	MJ/kg
Natural Gas	50

Source: IEA (2002)

3.5. Trade

3.5.1. Data Sources

Physical foreign trade data for Cuba proved difficult to compile, because data currently available for this country is quite insufficient. Both national and international statistics have been used for the acquisition of physical foreign trade data. Trade data on biomass is taken from the FAOSTAT Agricultural and Food Trade Statistics and Animal Commodity Balances. Trade data on fossil fuels is taken from the International Energy Agency database. Those biomass and fossil fuel commodities covered by FAO and IEA statistics are consistent and display high data quality. In general, Cuban foreign trade with mineral and metal commodities in physical units is poorly reported. Due to a lack of data availability, many finished and semi-finished manufactured products remain out of consideration.

Iron, nickel, cement, sand and gravel exports as well as iron, feed and fertilizer imports were calculated based on data from the UN Commodity Trade Statistics and the Anuario Estadistico de Cuba eds. 1989, 1998 and 2005.

3.5.2. Method of Calculation

Trade data used in this analysis is mainly restricted to raw materials reported by FAO and IEA statistics. Those great foreign trade flows (>100,000 m.t.) that were not covered by international sources (iron, nickel, cement, sand and gravel exports, and iron and feed imports) were calculated based on an estimation model based on price development (Tab. 12) and export-production ratio (Tab. 13).

Iron, nickel and cement exports were calculated based on price development using specific factors derived from the ratio of physical values from the United Nations Commodity Trade Statistics (available for 1999-2001) to monetary values reported in the Anuario Estadistico de

Cuba eds. 1989, 1998 and 2005. This relation was applied for all years, in order to estimate the physical trade volume with these commodities from 1970 to 2003.

Trade Commodity [t]= Monetary Value [pesos]*Factor [t/p]

Tab. 12: Trade Factors based on Price Development

Trade Commodity	Factor physical to monetary value[t/peso]
Iron Export	0.004
Cement Export	0.036
Nickel Export	0.029
Iron Imports	0.008
Animal Feed Imports	0.003

Source: Own calculation based on monetary and physical trade data reported in the Anuario Estadistico de Cuba 1989, 1998 and 2005 and the United Nations Commodity Trade Statistics Database (2007) for the years 2000-2002

Sand and Gravel Exports [t] = DE Sand and Gravel [t] * Factor

Sand and gravel exports were estimated, assuming that 0.3% of the sand and gravel extraction was destined for export.

Tab. 13: Trade Factor based on Export-Production Ratio

Export Commodity	Share Exports/Production
Sand and Gravel Export	0.0030

Note that foreign trade data is probably shaped by the applied method of calculation and does not allow further conclusions on the actual development of imports and exports of minerals and metal ores in this period.

Unlike domestic extraction, in the foreign trade section, live animals and animal products, e.g. meat, eggs and dairy products are accounted for. Besides secondary products made from biomass, also refined products made from fossil fuels are accounted for as imports and exports.

Foreign trade data refers to the form and mass weight of a good at the moment it crosses the administrative border. Nickel, for instance, is exported in the concentrated form of a conglomerate (mixed sulfide, oxide and sinter) and is therefore reported at its metal content. Nickel exports until 1978 originate from Schroeder (1982); export data of the later years comes from the Anuario Estadistico de Cuba 1989, 1998 and 2005, listed there as *non-ferrous ores and concentrates*.

3.6. Human Development Index (HDI)

3.6.1. Data Sources

There was no HDI available for all the years from 1970 to 2003. The human development index (HDI) for Cuba was calculated based on data from both national and international statistics. Data on life expectancy, literacy and gross enrollment between 1970 and 1985 were compiled from the UN Statistics Division http://unstats.un.org/unsd/databases.htm. Data for the later years were taken from the Anuario Estadistico de Cuba 1989, 1998 and 2005. Data on the GDP (PPP, USD) was taken from the IEA database.

3.6.2. Method of Calculation

The human development index (HDI) is a summary indicator measuring the average achievements of a country in the three key dimensions of the human development concept: long and healthy life (life expectancy at birth [A]), knowledge (measured by adult literacy 15+ [B1] and gross enrollment [B2]) and decent standard of living (GDP per capita PPP US$ [C]) shown in table 14 (Human Development Report, 2003).

The HDI represents the average value of these partial indices (A, B1, B2, C).

Calculation of the partial indices:

$$\text{Index} = \frac{\text{real value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

Tab. 14: Human Development Indicators

Matrix	Unit	Minimum	Maximum	Share of part index
A-Life Expectancy at Birth	years	25	85	100%
B1-Adult Literacy Rate	%	0	100	66.67%
B2-Schooling Rate	%	0	100	33.33%
C-Real Purchasing Power	USD PPP/cap	100	40,000	100%

Source: Human Development Report (2003)

The HDI is determined as an average value of the partial indices A, B ($^2/_3$*B1+$^1/_3$*B2). The partial indices A, B1 and B2 are calculated linearly whereas per capita real purchasing power values are incorporated in a logarithmic way.

The highest attainable value is 1, the lowest 0. The UNDP classifies countries according to their HDI in three different development stages.

Low human development: HDI < 0.5
Middle human development: HDI < 0.8 and ≥ 0.5
High human development ≥ 0.8

For calculating the combined school enrollment for Cuba, the gross tertiary female enrollment rate was used (2005: 78%) as suggested in the Human Development Indicators Database.

Note the calculated HDI for Cuba is slightly higher than the HDI published by the UNDP.

4. Outcomes

4.1. Domestic Extraction (DE)

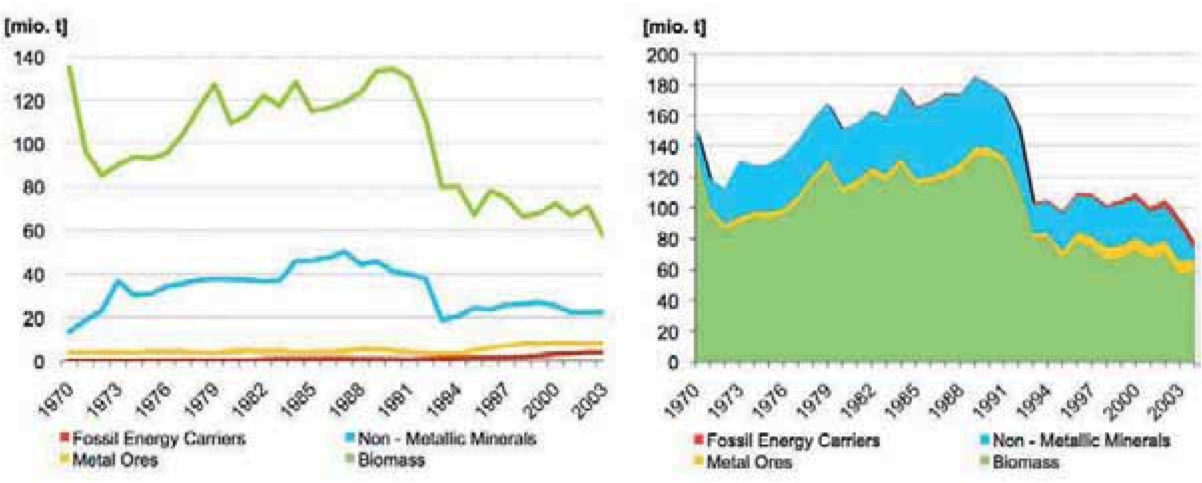
Cuba's domestic extraction reaches its maximum in 1989 at 185 million tons, with a minimum of 113 million tons in 1972 and of 73 million tons in 2004 (Fig. 9).

Three phases are observed in the development of domestic extraction: An incremental period of growth during the 1970s and 1980s, during which domestic extraction increased from 113 million tons (12.7 t/cap/yr) in 1972 to 185 million tons (17.6 t/cap/yr) in 1989 at an average growth rate of 5.5% per year. What is characteristic of the 1980s is a continuous growth of domestic extraction, gently increasing on a relatively high level with marginal fluctuations ranging from 160 million to 180 million tons.

The year 1989 marked a significant point of change in the Cuban economy in social, economic and environmental terms. In that year domestic extraction reached its peak during the time period investigated, totaling 185 million tons or 17.6 t/cap/yr. But 1989 was not only the year of the highest domestic extraction, it also marked the beginning of a period of declining extraction.

During the 1990s material flows remained relatively stable on an overall lower level. Between 1989 and 1995 domestic extraction dropped almost half, amounting to 98 million tons (8.9 t/cap/yr) in 1995. From the mid-nineties, domestic extraction fell another 20% amounting to no more than 77 million tons (6.8 t/cap/yr) in 2004.

Fig. 9: Domestic Extraction



Source: Own calculation

The average share of the four main material categories of the total domestic extraction equals $^{3}/_{4}$ biomass, $^{1}/_{5}$ - $^{1}/_{4}$ non-metallic minerals (mainly construction minerals) and 3-9% metal ores. In terms of weight, domestic extraction of fossil fuels plays only a minor role in Cuban physical economy. In the course of time there are only slight variances of this composition (Tab. 15).

Tab. 15: Share of Material Categories in DE

Material Category	1970s	1980s	1990s	2000s*
Biomass	75.2%	71.4%	71.2%	69.1%
Metal Ores	3.0%	2.7%	4.6%	8.8%
Non-Metallic Minerals	21.6%	25.4%	22.9%	20.1%
Fossil Fuels	0.2%	0.4%	1.2%	3.4%

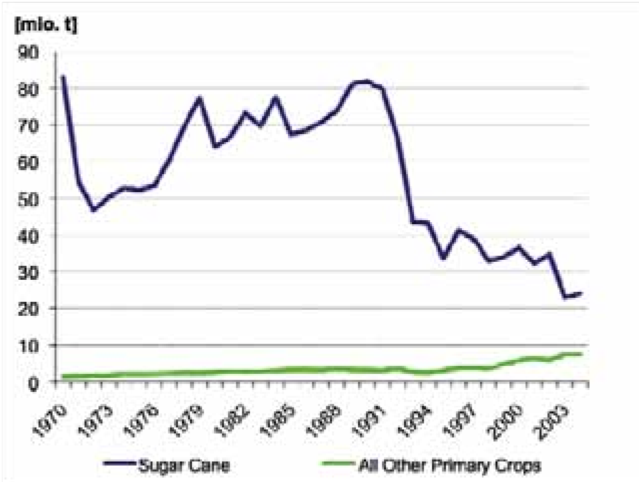
*2000-2003

Source: Own calculation

Biomass extraction represents the major part of DE contributing an average of 72% of the total domestic extraction between 1970 and 2003. The huge amounts of extracted biomass and the relatively high shares of biomass of the overall physical economy reflect the importance of agriculture for the Cuban economy and its role as a biomass producing and exporting country.

In 1972, biomass extraction amounted to 85 million tons, increasing steadily until it culminated again in the years 1979 (127 million tons or 13.2 t/cap/yr), 1984 (128 millions tons or 12.8t/cap/yr) and finally 1990 (134 million tons or 12.6t/cap/yr). The magnitude of the biomass extraction flow mainly is determined by huge amounts of extracted sugar cane and the production of sugar residues, accounting for 80% of the biomass flow (Fig. 10).

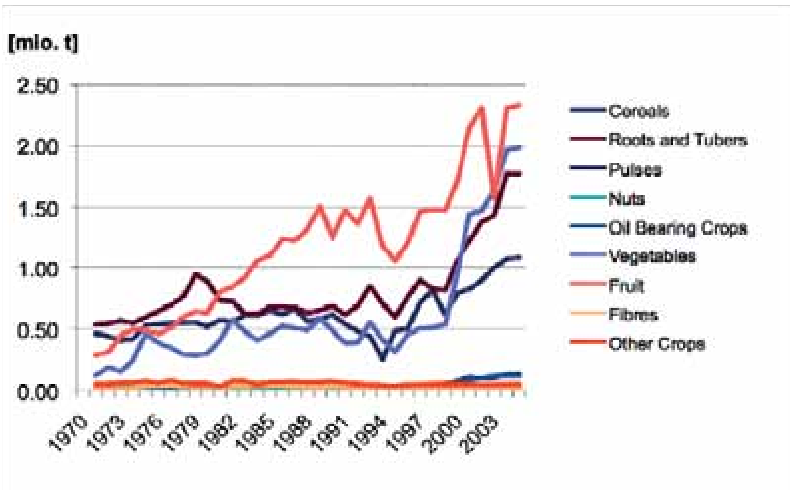
Fig. 10: Domestic Extraction of Primary Crops



Source: Own calculation based on FAO (2004)

Other important primary crops (> 1 million t/yr, green matter) produced in Cuba are rice, grapefruit, oranges, tomatoes, potatoes, sweet potatoes, cassava, bananas and plantains (Fig. 11). It is interesting to note that there is no wheat production in Cuba, probably due to climatic conditions. The extraction of most primary crops, especially sugar cane, is adversely affected by the economic crisis showing regressive production in the first half of 1990s and recovery in the mid-nineties.

Fig. 11: Most Important Primary Crops exluding Sugar Cane



Source: Own calculation based on FAO (2004)

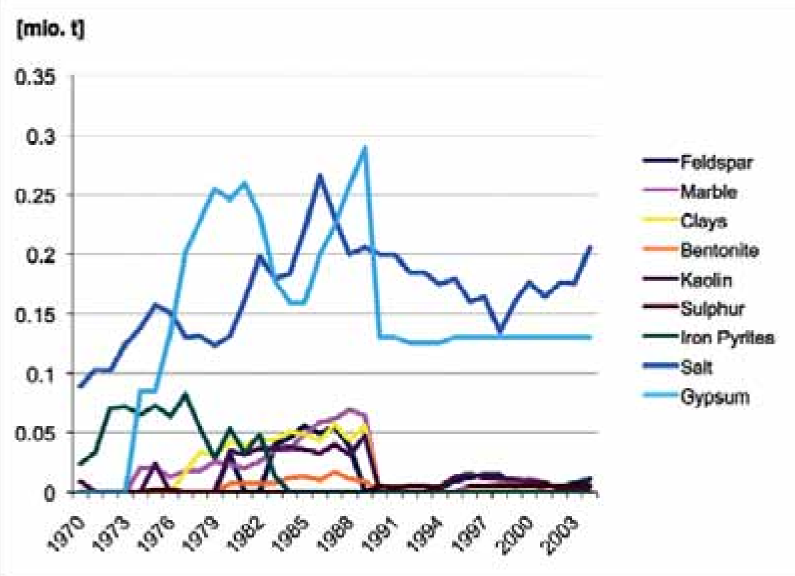
After 1995 some crops gained relative importance. The extraction of rice, beans and cocoyam rose, as well as the extraction of some vegetables (cabbages, cucumbers, onions and pumpkins) and tropical fruit (mangoes, papayas and coconuts). However, during the 1990s overall biomass extraction dropped almost 60% to less than 60 million (57 million) tons in 2003. This significant decrease in the extraction of biomass was mainly caused by falling sugar cane extraction, which went together with declining sugar exports, decreasing sugar cane yield and harvest area during the 1990s.

Non-metallic minerals comprise industrial and construction minerals. They altogether account for 20-25% of the total domestic extraction. The extraction of non-metallic minerals is dominated by large amounts of extracted construction minerals, mainly sand, gravel, crushed stone and limestone, accounting for 99% of the total mineral production. Construction minerals are low-cost commodities, abundant in nature and are broadly used in civil engineering. Construction minerals are relevant to the Cuban economy, but quite insignificant in monetary terms due to their low economic value and low trade intensity.

Construction minerals extraction follows a similar trend as the biomass flow, so typical for Cuba. The extraction of construction minerals amounted to 13.4 million tons (1.6 t/cap/yr) in 1970, increased steadily until 1989 (45.3 million tons or 4.3 t/cap/yr), and dropped 60% in the early 1990s to 18.8 million tons (1.7 t/cap/yr) extracted in 1993. Throughout the 1990s domestic extraction of construction minerals remained quite stable at an overall lower level, amounting to 22.3 million tons or 2 t/cap/yr in 2003.

Industrial minerals play only a minor role in the Cuban physical economy, accounting for less than 0.3% of the total domestic extraction. Among the most important industrial minerals extracted in Cuba are gypsum and salt (>100,000 t/yr) and smaller quantities of marble, feldspar, iron pyrites, bentonite, kaolin and clays (< 50,000 t/yr) There are some discontinuities in the extraction of marble, bentonite, magnesite and clays after 1989 (Fig. 12). There are two possible reasons for these disruptions: breaks might either be caused by a lack of data availability or a real breakdown of the Cuban mineral industry after 1989. The overall lower figures reported after 1995 indicate a reduced domestic extraction of industrial minerals from 1989. However, in terms of weight, the domestic extraction of industrial minerals is low compared to high volumes of extracted construction minerals.

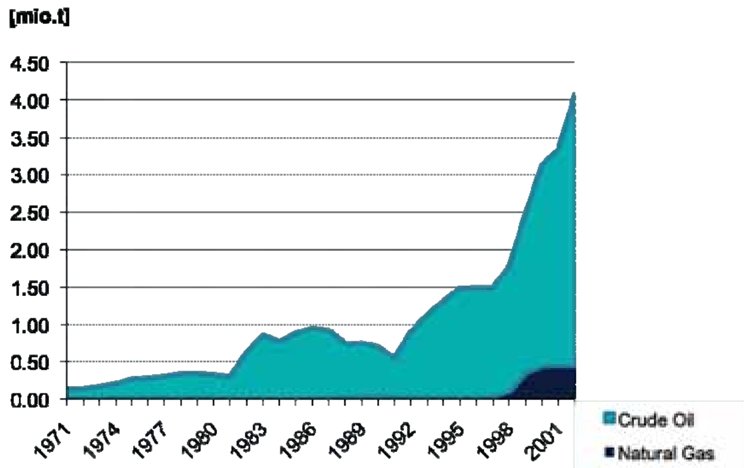
Fig. 12: Domestic Extraction of Industrial Minerals



Source: Own calculation based on United Nations Industrial Commodity Production Statistics Database (2004) and USGS (2006)

Fossil fuel extraction is of minor importance for the Cuban economy. It represents a relatively small flow compared to overall domestic extraction, accounting for 0.3% to 3.4%. Nevertheless, fossil fuel extraction gained importance during the 1990s (Fig. 13). In that decade fossil fuels extraction increased rapidly due to higher levels of domestic oil production at an average growth of 15.7% per year. The extraction of oil doubled from 1.5 million tons in 1997 to almost 3 million tons in 2001. During the energy crisis as a consequence of economic recession in the early nineties, Cuba increased the exploitation of domestic crude oil resources, in order to substitute expensive oil imports. The production of crude oil was increased particularly in the 1990s, mainly due to foreign investments and the use of more efficient technology. Cuba's natural gas production, which is all associated gas obtained from oil recovery, started in the late 1990s only and rose significantly from 28,000 t/yr in 1997 to 444,000 t/yr in 2001. It should be mentioned at this point, that there is no domestic extraction of coal in Cuba.

Fig. 13: Domestic Extraction of Fossil Energy Carriers

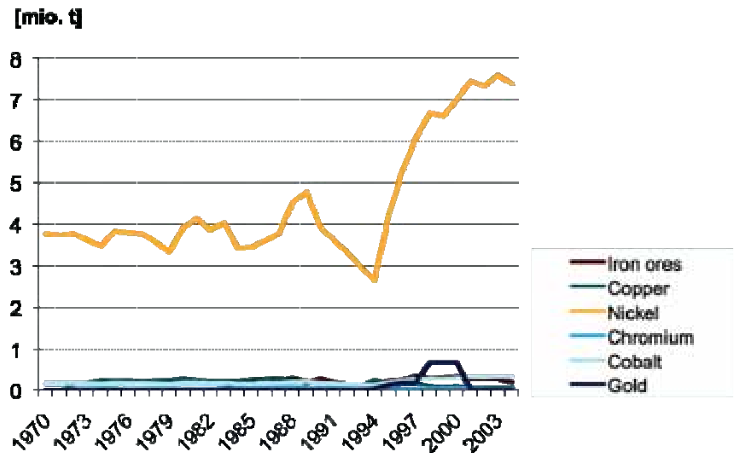


Source: Own calculation based on IEA (2002)

The extraction of metal ores is relatively low compared to other material categories. Although the share of metal ores is small (2.7% to 8.8% of the total domestic extraction), a dynamic growth can be registered in the observed period, from 3.8 million tons or 0.44 t/cap/yr in 1970 to 7.6 million tons or 0.67 t/cap/yr in 2003 (Fig. 14, Tab. 15).

Cuba is a country with comparatively small ore deposits. The most important metal ore is nickel, which accounts for 3.5% of the total domestic extraction or 88% of the total ore extraction. Nickel extraction amounted to roughly 3 mio. tons to 4 mio. tons gross ore between 1970 and 1989, dropped almost half between 1989 and 1994 and increased rapidly until 2003 (by factor 3 from the mid-nineties). A more detailed description of the nickel flow and a short discussion of its determinants and consequences can be found in section 5.3.2.

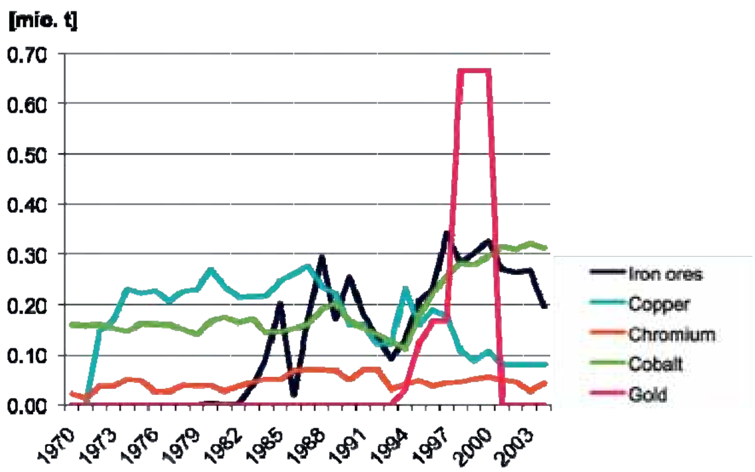
Fig. 14: Domestic Extraction of Metal Ores



Source: United Nations Industrial Commodity Production Statistics Database (2004) and USGS (2006)

Extracted metal ores other than nickel are copper, chromium, gold, iron ore, and cobalt as a by-product of nickel extraction (Fig. 15). All metal ores reacted sensitively to economic depression in the early nineties with declining production figures and started to rise again in the mid-nineties. The production of small quantities of gold started in 1994 with the opening of a gold-mine in Castellanos, 125 km west of Havana. However, the mine closed again in 1999 and gold extraction terminated (Rabchevsky, 1994).

Fig. 15: Metal Ores Other Than Nickel



Source: United Nations Industrial Commodity Production Statistics Database (2004) and USGS (2006)

Table 16 shows domestic extraction in the four main material categories, in terms of total mass flows, mass per capita and per unit of land area.

Tab. 16: Domestic Extraction by Material Categories

Domestic Extraction		1970	1975	1980	1985	1990	1995	2003
Total	mio. t	152.4	128.2	151.4	165.9	180.6	97.7	92.0
	t/cap/yr/	17.9	13.8	15.6	16.4	17.0	8.9	8.1
	t/ha	13.9	11.7	13.8	15.1	16.5	8.9	8.4
Biomass	mio. t	134.82	92.9	109.36	114.85	134.24	66.96	57.14
	t/cap/yr	15.82	9.98	11.26	11.35	12.63	6.11	5.06
	t/ha	12.28	8.46	9.96	10.46	12.22	6.10	5.20
Metal Ores	mio. t	3.97	4.27	4.43	4.14	4.58	4.91	8.3
	t/cap/yr	0.47	0.46	0.46	0.41	0.43	0.45	0.73
	t/ha	0.36	0.39	0.40	0.38	0.42	0.45	0.76
Non Metallic Minerals	mio. t	13.47	30.75	37.28	46.08	41.11	24.32	22.52
	t/cap/yr	1.58	3.3	3.84	4.56	3.87	2.22	1.99
	t/ha	1.23	2.8	3.39	4.20	3.74	2.21	2.05
Fossil Energy Carriers	mio. t	0.14	0.27	0.33	0.88	0.7	1.48	4.07
	t/cap/yr	0.02	0.03	0.03	0.09	0.07	0.14	0.36
	t/ha	0.01	0.02	0.03	0.08	0.06	0.14	0.37

Source: Own calculation

4.2. Trade

Data on trade with biomass and fossil fuels is accurate and consistent. Regarding minerals and metals only large trade flows were taken into account, due to lack of data. No manufactured products were considered.

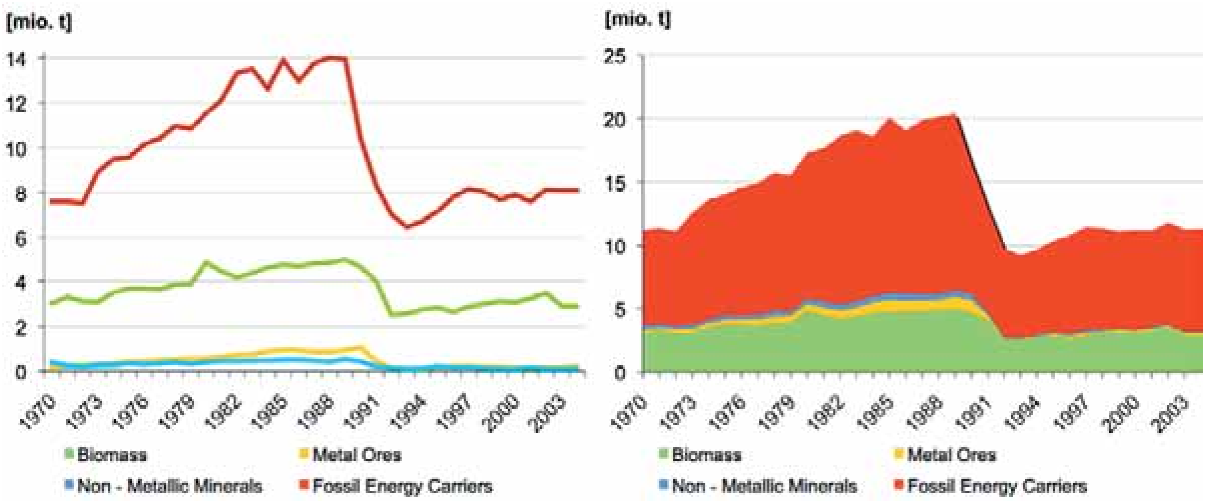
The most important export commodity in terms of weight is sugar accounting for 80% of all physical exports between 1970 and 2003; followed by smaller quantities of metal (iron ore and nickel) and mineral exports (sand, gravel, cement). The largest import volumes derive from fossil fuels (particularly oil imports) accounting for 70% of all physical imports followed by biomass imports accounting for an average of 25%. Most important biomass import flows are wood, fish and food imports consisting of cereals, dairy and animal products.

4.2.1. Imports

During the 1970s the physical imports to the Cuban economy increased about 150% from a total of 11 million tons or 1.3 t/cap/yr (1970) to 17 million tons or 1.8 t/cap/yr (1980) and reached a maximum of over 20 million tons (2.0 t/cap/yr) in 1989. Overall imports collapsed more than half between 1989 and 1993 and remained stable in the 1990s, ranging from 9.2 (0.9 t/cap/yr) in 1993 to 11.2 million tons (1.0 t/cap/yr) in 2003. Collapsing overall imports in the early nineties were mainly due to the absence of crude oil imports (Fig. 16). Dropping imports can be seen in all four main material categories.

Fossil fuels (in particular oil and oil products) and biomass (in particular food) imports represented the largest physical import flows, at a ratio of 3:1, altogether accounting for 91% to 98% of the total imports between 1970 and 2003. Thus, the development of the overall imports was to a large extent determined by oil and to a smaller extent by food imports. Beside fertilizer and iron imports, there were no significant amounts of metal ores and non-metallic minerals imported during the observed period. The imports of all material categories in the medium term grew until 1989 and dropped drastically, as a consequence of the economic recession in the early 1990s. The relative share of the material categories on the physical import volume, however, remained quite stable throughout the investigation period (biomass 25%, metal ores 3%, minerals 2%, fossil fuels 70%).

Fig. 16: Physical Imports



Source: Own calculation

Fossil fuels represented the largest imports flow highly determined by crude oil, diesel and fuel oil, accounting for 90% to 95% of all imported fossil energy carriers (Tab. 17). In the 1970s crude oil accounted for $^2/_3$ of fossil imports, while diesel and fuel oil together made up $^1/_3$. This trend is reversed in the 1990s.

Tab. 17: Crude Oil, Diesel and Fuel Oil as a Share of Fossil Fuel Imports

	1970s	1980s	1990s
Crude Oil	68%	59%	25%
Diesel and Fuel Oil	27%	35%	67%

Source: Own calculation based on IEA (2002)

Other imported fossil fuel commodities were small quantities of hard coal, lignite, kerosene, liquefied petroleum gases, motor gasoline, aviation gasoline, naphtha and lubricants. In terms of weight, these commodities were of minor importance, accounting for 4% to maximum 10% of the total fossil fuel imports.

In the first two decades fossil fuel imports grew constantly by 160% from 7.5 million tons (0.9 t/cap/yr) in 1971 to 12 million tons (1.2 t/cap/yr) in 1981, reaching their maximum in 1988 amounting to 14 million tons or 1.3 t/cap/yr. In the early nineties fossil fuel imports fell drastically by 54% down to 6.5 million tons in 1993, while domestic crude oil extraction still continued to rise. That shows how from 1990 the domestic oil supply increasingly relied on domestic oil extraction. From the mid-nineties onwards fossil fuel imports could be maintained at a relatively stable level of 7.0 million to 8.0 million tons or 0.7 t/cap/yr.

Biomass imports amounted to 3.0 to 4.0 million tons in the 1970s, rising above 4 million tons during the 1980s and peaking in 1989 at 5 million tons (0.5 t/cap/yr). In the beginning of the nineties, biomass imports dropped half from 5 million tons imported in 1989 down to 2.5 million tons in 1992. Since then the physical import volume of biomass increased gradually, amounting to 3.5 million tons (0.3 t/cap/yr) in 2003. The share of biomass imports lies quite stable at around 25% of the total Cuban imports. Biomass imports consist mainly of food imports like cereals, dairy and animal products, accounting for approximately 83% of the total biomass imports. In the 1990s, the share of animal products and primary crops even rose above 90% of all biomass imports. Table 18 shows the most important biomass imports.

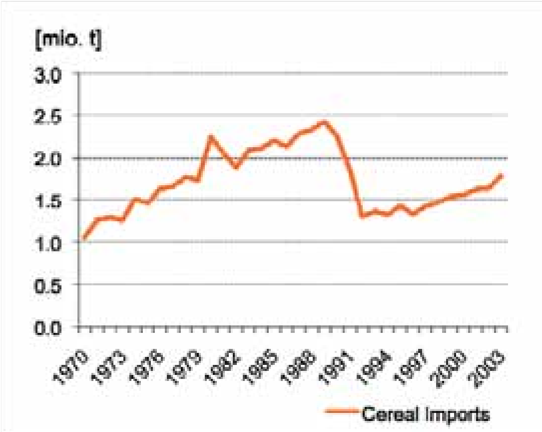
Tab. 18: Wood, Fish, Cereals, Dairy and Animal Imports as a Share of Biomass Imports

Biomass Imports	1970s	1980s	1990s
Timber and Wood Fuel	11%	13%	3%
Fish	9%	4%	1%
Cereals	42%	47%	50%
Dairy Products	21%	13%	16%
Meat and Live Animals	4%	5%	5%
Fodder Crops	3%	5%	5%
Oil Bearing Crops	5%	8%	11%

Source: Own calculation based on FAO (2004)

Cereal imports, accounting for 12% of import flow, consist mainly of wheat, corn and rice imports. Figure 17 shows the development of cereal imports between 1970 and 2003.

Fig. 17: Cereal Imports



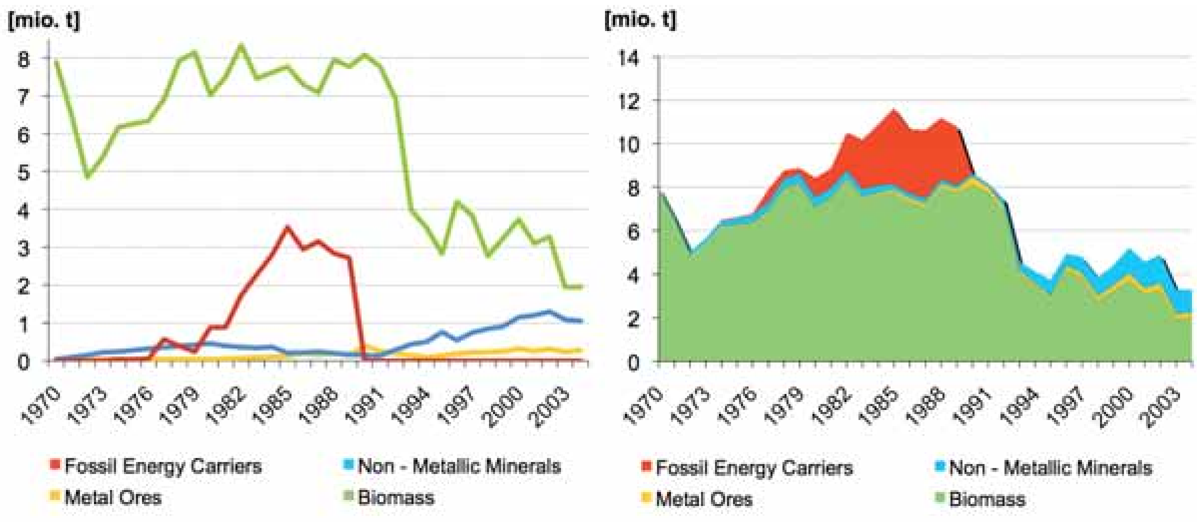
Source: FAO (2004)

4.2.2. Exports

Overall physical exports increased constantly from 8 million tons (0.94 t/cap/yr) in 1970 to 10.8 million tons (1.03 t/cap/yr) in 1989. In 1972, the export volume dropped to 5 million tons (0.57 t/cap/yr) for a short term; this trend was in particular due to declining sugar exports, by 40% at the time. In 1985 physical exports peaked at 11.6 million tons (1.15 t/cap/yr) (Fig. 18).

Between 1989 and 1995, overall exports dropped sharply as a direct consequence of the strongly reduced sugar exports and absent fossil fuel exports. Sugar exports fell minus 60%, while overall exports fell minus 65%, from 11 million tons (1.07 t/cap/yr) exported in 1989 to below 4 million tons (0.34 t/cap/yr) exported in 1995. This clearly shows to what great extent the development of exports is determined by large amounts of exported sugar cane, accounting for 80% of all physical exports. Between 1993 and 2003, overall physical exports stabilized at a level of 3.0 million to 5.0 million tons or 0.3 to 0.45 tons per capita.

Fig. 18: Physical Exports

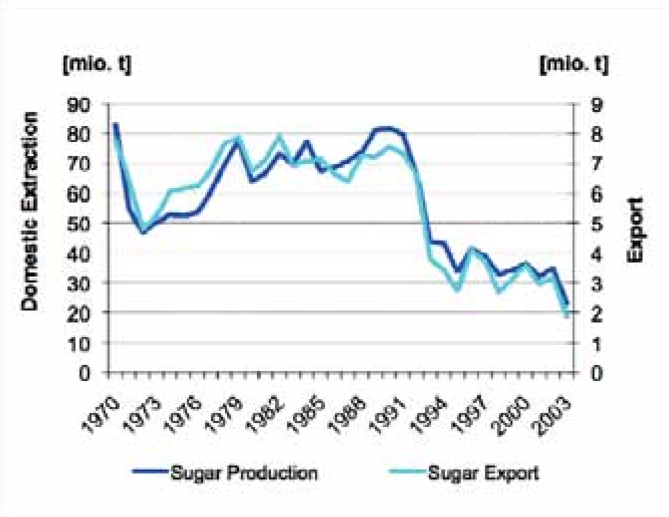


Source: Own calculation

Biomass exports represented the largest physical export flow, accounting for a maximum of 99% in 1970, and a minimum of 59% of the total physical exports in 2003. The high level of biomass exports is almost exclusively based on the development of the sugar exports (sugar raw, refined and molasses) during this period, accounting for 95% of all biomass exports. Other exported biomass products (<5%) are fruit (citrus fruit, e.g. oranges, grapefruit and lemon), vegetables (fresh and prepared) and other crops (stimulants, e.g. tobacco leaves, coffee, alcoholic beverages and cigars).

At a lower level (by factor 10) the sugar export curve reflects the trend of the domestic extraction (Fig. 19). The high degree of correlation between production and export of sugar cane indicates a high export quota and demonstrates how strongly sugar production is focused on exports. Even slight fluctuations in sugar production have an impact on export figures. Between 1970 and 2003, about 10% of the total sugar cane extraction was exported in processed form as sugar and sugar products.

Fig. 19: Sugar Production and Export



Source: FAO (2004)

The high share of sugar exports shows the great importance of sugar cane for the Cuban economy as a generator of foreign currency, emphasizing Cuba's traditional role as one of the world's most important sugar exporting countries (Funes, 2004).

Fossil fuel exports gained importance during the 1980s. This material group grew significantly in the 1980s mainly due to rising exports of crude oil, motor gasoline, diesel oil, heavy fuel oil and naphtha, accounting for 10-30% of total exports. Amounting to less than 1 million ton in 1980, fossil fuel exports rose to 3.5 million tons in 1985 and equaled 2.7 million tons before they disappeared in 1989. Before and after the eighties no significant amounts of fossil energy carriers were exported.

Mineral exports, consisting mainly of construction mineral exports (cement, limestone, sand and gravel) pro rata replaced fossil fuel exports in the 1990s. The export shares of metal ores rose constantly due to growing nickel and iron exports, especially from the mid-nineties (Tab. 19).

Tab. 19: Export Shares of Material Categories

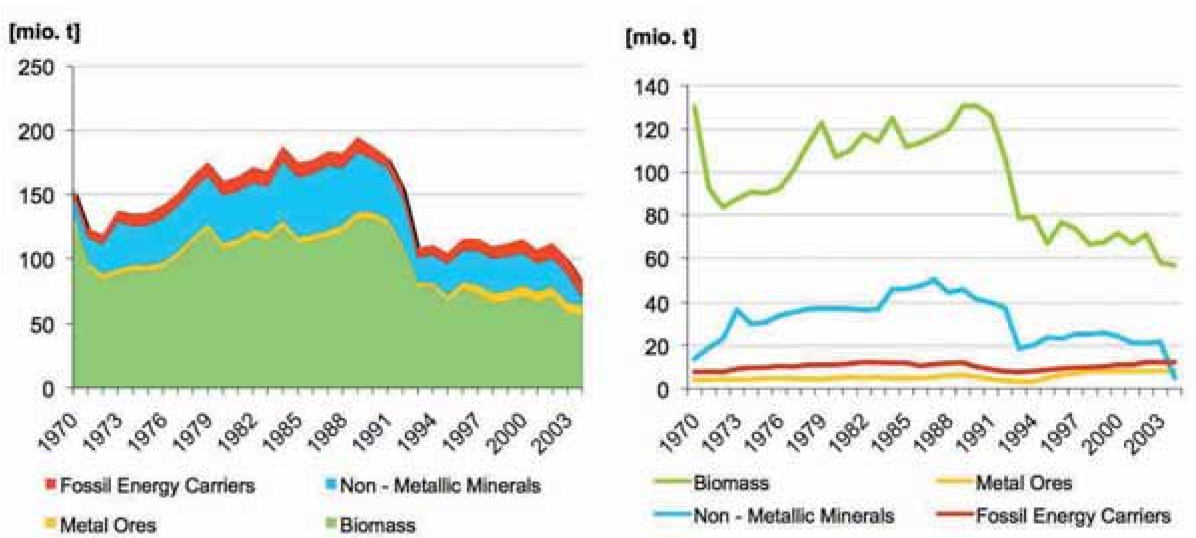
	1973	1983	1993	2003
Biomass	95.3%	73.4%	87.1%	59.4%
Metal Ores	0.7%	0.9%	3.3%	7.3%
Non-metallic Minerals	4%	3.4%	9.6%	33.3%
Fossil Energy Carriers	0%	22.3%	0%	0%

Source: Own calculation

4.3. Domestic Material Consumption (DMC)

The DMC as an indicator for the domestic material consumption follows a similar trend as domestic extraction (Fig. 20). Material consumption increased until 1989 and sharply declined during the economic crisis in the nineties. The share of the individual material categories of the total material consumption remained relatively constant during the investigation period: biomass (67%), ores (4%), minerals (21%) and fossil energy carriers (7%).

Fig. 20: Domestic Material Consumption



Source: Own calculation

During the prosperous 1970s, absolute material consumption grew 40% from 120 million tons (1971) to almost 170 million tons (1979) with an average growth of 5% per year. This trend continued in the 1980s, when average material consumption reached the considerable level of 160 to 180 million tons.

This trend is also reflected in the increasing DMC per capita and per land area respectively. Per capita material consumption increased along medium population growth (from 8.5 milllion to 10.5 million inhabitants) during the first two decades from 14 t/cap/yr (1971) to 18 t/cap/yr (1989). The DMC per land unit grew from 11 t/ha (1971) to roughly 18 t/ha (1989) (Tab. 20). Since the land area remains constant, latter directly reflects the development of the absolute DMC. The high DMC per land unit is mainly determined by large quantities of extracted sugar cane. That clearly indicates to what great extent land area and thus natural ecosystems are affected by extensive sugar cane cultivation.

Table 20 shows domestic material consumption in the four main material categories, in terms of total mass flows, mass per capita and per unit of land area.

Tab. 20: Domestic Material Consumption by Material Categories

Domestic Material Consumption		1970	1975	1980	1985	1990	1995	2003
Material Intensity	kg/USD	11.6	7.75	7.8	5.65	6.11	4.9	2.7
DMC, Total	mio. t	155.6	135.6	160.3	176.8	187.4	104.3	100.0
	t/cap/yr	18.30	14.6	16.5	17.3	17.6	9.5	7.3
	t/ha	11.57	12.35	14.6	15.94	17.07	9.5	5.3
Biomass	mio. t	130.0	90.3	107.2	111.8	130.8	67.0	58.1
	t/cap/yr	15.3	9.7	11.0	11.0	12.3	6.11	5.1
	t/ha	11.83	8.23	9.76	10.18	11.91	6.10	5.29
Metal Ores	mio. t	4.1	4.7	5.0	5.0	5.2	4.9	8.2
	t/cap/yr	0.48	0.5	0.5	0.49	0.49	0.45	0.73
	t/ha	0.37	0.42	0.45	0.45	0.48	0.45	0.75
Non Metallic Minerals	mio. t	13.8	30.8	37.2	46.3	41.0	23.8	21.5
	t/cap/yr	1.62	3.31	3.8	4.6	3.9	2.17	1.9
	t/ha	1.26	2.81	3.39	4.22	3.77	2.16	1.96
Fossil Energy Carriers	mio. t	7.7	9.8	11.0	11.8	10.0	8.7	12.2
	t/cap/yr	0.91	1.05	1.13	1.17	0.94	0.79	1.08
	t/ha	0.7	0.89	1.0	1.08	0.91	0.79	1.11

Source: Own calculation

4.4. *Material Intensity (MI)*

Material intensity refers to material consumption (t) per dollar of economic output (GDP in constant USD). In Cuba, sinking material intensity or rising resource efficiency could be observed between 1970 and 2003 (Fig. 21). In the observed period, material intensity declined continuously from 11.6 kg/USD (1970) to 2.7 kg/USD (2003); this is a reduction by 77%. Between 1970 and 1985 material intensity declined from 11.6 kg/USD to 5.6 kg/USD. This development was particularly influenced by the fact that in this period the economy grew faster than overall material consumption. The only period where the decline of material intensity came to a halt was between 1985 and 1991, before it accelerated in the 1990s. It is eye-catching that there is no radical break between 1989 and 1993. That simply shows how strong economic growth is linked with material use, since declining material intensity shows nothing more than the relationship of economic development and resource consumption. During the 1990s, material intensity dropped further from 6.1 kg/ USD (1990) to 2.7 kg/USD (2003).

Fig. 21: Material Intensity

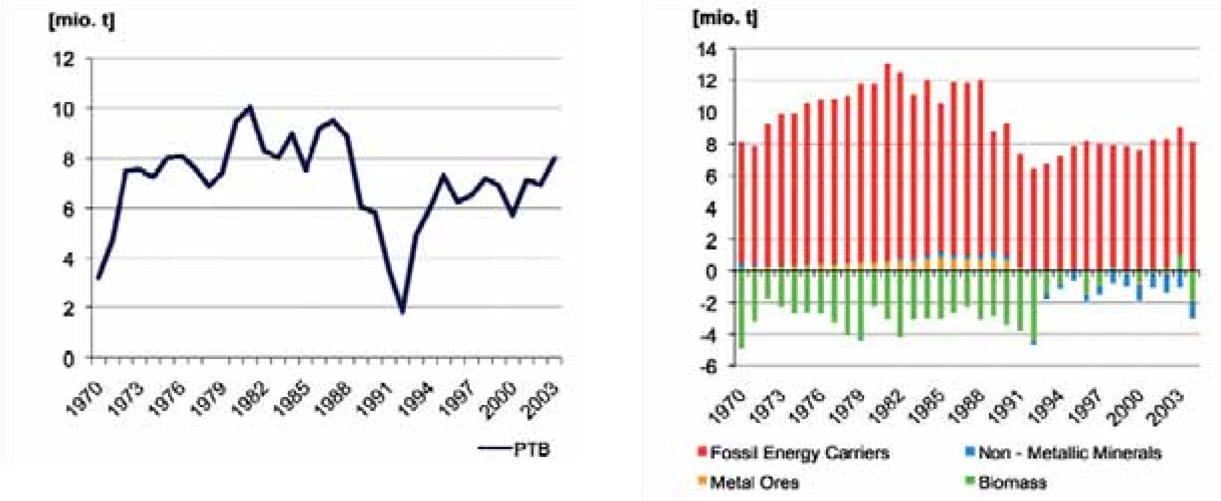
Source: Own calculation

4.5. The Physical Trade Balance (PTB)

Balancing imports against exports, Cuba is a net-importer of materials (Fig. 22). Net imports amounted to 2.3 million tons in 1970 and peaked in the prosperous 1980s exceeding 10 million tons (1981). During these decades the growing PTB was to a great extent determined by increasing quantities of oil imports. In the same way, lacking oil imports were reflected in the physical trade balance after 1989.

In 1991, net imports amounted to 3.5 million tons. In just one year, they dropped almost half to less than 2.0 million tons in 1992. The decline of the physical net imports was mainly a consequence of collapsing fossil fuel imports in the early nineties. Between 1994 and 1999 the physical trade balance rose again and fluctuated around 6.0 to 7.0 million tons. From the mid-nineties, the rising PTB was mainly caused by declining sugar exports. The collapse and overall lower level of PTB after 1989 were the result of a dynamic mix of crashing crude oil imports and reduced sugar exports.

Fig. 22: Physical Trade Balance



Source: Own calculation

5. The Cuban Physical Economy

5.1. Structure

This chapter discusses the structure of the physical economy and trends of dematerialization, material consumption and material intensity.

Cuba has a relatively high material consumption, with 10.3t/cap/yr, or respectively up to 18 t/cap/yr in times of industrialization of the command economy. Cuba's DMC is clearly higher than the DMC of most Central American countries or European industrial nations. The high DMC for Cuba as compared on an international scale (2000, DMC [t/cap/yr]: Cuba: 10.3; India: 5.5; Italy: 12.5 – source: Krausmann et al. (2008a) needs to be seen mainly as a consequence of extensive sugar cane cultivation and is influenced by the high moisture content of sugar cane (83% moisture). Compared to the high level of sugar cane extraction and food imports, sugar exports appear low since these are traded in a concentrated form as refined cane sugar, syrups and molasses. In this way, apparently much material remains within the Cuban economic system. In Cuba, an average of 90% of the material associated with sugar cane production destined for export remains on the island.

The same applies to the DMC of nickel. Nickel mining entails the mobilization of huge amounts of material since this metal holds a relatively small metal content of less than 1%. In order to obtain 10 kg nickel 1 ton gross ore needs to be extracted. Since nickel is exported in concentrated form of an intermediate product even 98% "waste" associated with the raw material nickel remains on Cuban territory.

The DMC therefore is also referred to as an indicator for the *domestic waste potential* (Weisz et al., 2006). The DMC is used for indicating environmental pressures. It demonstrates to what great extent the material burden and environmental costs of raw material exports lie within the territory of the exporting country.

The DMC for non-metallic minerals reflects the DE of minerals. This has to deal with the fact that construction minerals are rarely traded low-cost commodities, rather extracted and consumed in situ since transport costs are high compared to production costs (Weisz et al., 2006). As a consequence, the relatively high DMC for minerals is due to large quantities of extracted construction minerals and comparatively small amounts of exported sand, gravel and cement. Hence, for construction minerals a DE/DMC ratio of almost 1 arises, which expresses the localism of this material group.

In terms of weight, the DMC of fossil energy carriers and metal ores turns out to be relatively low. The development of metal ores, however, features dynamic growth determined by an intensification of nickel mining from the mid-nineties. A more detailed illustration of resource consumption by material categories and material intensity can be found in table 20.

As mentioned before, the Cuban DMC shows relatively strong fluctuations. The economic crisis in the early 1990s, declining sugar production, low construction activity, and last but not least, strongly reduced oil imports led to a drastic reduction of the DMC. During the 1990s the absolute material consumption fell 47% from 195 million tons (1989) to 105 million tons (1995). In the same period, the DMC per capita dropped even more (minus 50%) from 18t/cap/yr to 10 t/cap/yr due to continuous population growth. This development also needs to be interpreted as an expression of reduced economic activity and material shortage as a consequence of the scarcity economy after 1989. In the course of the 1990s, the DMC remained largely constant, around 100 million tons (10t/cap/yr).

Between 1970 and 2003 a relative decoupling of material consumption (DMC) and economic development (GDP) was observed. While dematerialization between 1970 and 1989 was the result of a relative decoupling due to moderate growth of material consumption along with strong economic growth, dematerialization after the economic collapse in 1989 was the result of an absolute decoupling due to material stability (stagnant DMC) together with accelerated economic growth (rising GDP) between 1993 and 2003. The apparent dematerialization after 1993 occurred not through an increase in efficiency but through reduced material use (lower/stable DMC) as a consequence of the economic crisis. While GDP grew 40% after 1993, DMC fell 7%.

Accordingly, material intensity, which expresses the relationship of economic development and material use (DMC/GDP [t/kg]), declined continually during the observed period. Material intensity only came to a halt in the 1980s and did not indicate the break observed for DE, DMC and GDP between 1989 and 1993. That shows how closely economic growth is connected to material use.

Signs for dematerialization after 1993 indicate structural change and a shift from an export oriented, agricultural development model towards a quality based development focusing on services. The decoupling of material use and economic growth between 1993 and 2003 occurred along with a growing tourist industry, which increasingly replaced sugar production as the main source of income and foreign currency. By 2003 a major share of the GDP was generated by the tourist industry (Mesa-Lago, 2005). Nickel extraction might have increased GDP between 1993 and 2003, but did not affect DMC, because nickel exports in terms of weight were only of minor importance.

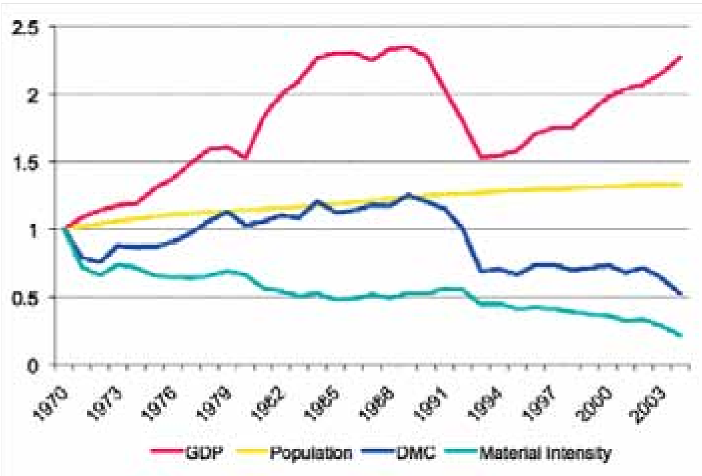
In summary, Cuba increased its national income along declining material intensity and reduced overall material consumption. On the other hand, the Cuban case shows how closely economic growth is linked with material use.

5.2. Development

In this section the development of several socio-economic indicators will be discussed in the context of Cuban development between 1970 and 2003.

The development of the Cuban physical economy follows three phases. These phases are reflected in the development of most material flows, economic and physical parameters. GDP, HDI, PTB, DMC, DE, imports and exports are all affected by this development, in such a way typical for Cuba: Increase (1970-1989), decline (1989 and early 1990s) and stabilization (after 1993). Only material intensity (DMC/GDP) shows a linear decline along moderate population growth (Fig. 23).

Fig. 23: GDP, DMC, Material Intensity and Population



Source: Own calculation

Growth (1970-1989)

Economic and physical growth, and a high level of most material flows and MFA derived indicators were characteristic of this period (Tab. 21). The 1970s and 1980s were a prosperous period in terms of social, economic and industrial development. Various factors stimulated economic growth and material use in this period.

The integration into COMECON in 1972 allowed access to large and secure selling markets, loans and economic assistance. It granted sales at preferential prices due to long-term trading agreements; in addition, five-year plans helped in setting productive goals and planning the economic output. Large investments in the basic industries, increased construction activities, high fossil fuel imports and intensive land use based on sugar cane production, were characteristic for this period. These factors led to industrial and economic development, but also increased the dependence on oil imports and encouraged an agricultural development model based on the export of cash crops. In that period the extraction and the export of raw materials (sugar and nickel) were essential activities for earning foreign currency, financing industrialization and social development. The rising PTB in that period was highly determined by large amounts of fossil fuel imports.

Collapse and economic recession (1989-1993)

Most material flows, physical and economic indicators crashed between 1989 and 1993. GDP, DMC and PTB, which had increased continually during the 1970s and 1980s, plunged down between 1989 and 1993 (Tab. 21).

The collapse of the former USSR in 1989 marked a radical point of change in socio-economic and environmental terms. Changing patterns of trade (the loss of foreign trading partners, important export markets and long-term contracts) provoked a structural change of the physical economy and its energy system. Fossil fuel imports and sugar exports, necessary for social, industrial and economic development, crashed in 1989. The economic crisis in the early nineties was accompanied by an energy crisis. A lack of foreign currency forced Cuba to reduce fossil fuel imports. Energy shortage and lacking investments in turn resulted in low construction activities and maintenance problems of industrial facilities and infrastructure.

Recovery and restructuring (1993-2003)

Most material flows and MFA derived indicators recovered after 1993 and stabilized on an overall lower level. While GDP rose after 1993, DMC flattened mainly due to declining sugar cane extraction and low construction activity. Material use that showed some volatility with economic growth before 1989, lowered and remained quite stable in this period. At this stage a shift from the traditional specialization in agricultural exports towards a service economy took place, with the important exception of nickel exports, which increased during this period. The overall lower level of PTB was mainly due to reduced fossil fuel imports during the 1990s. Fossil fuel imports decreased considerably in favor of increasing domestic extraction of crude oil and energy recovery from sugar cane by-products.

Tab. 21: Phases of Development

	1970-1989	1989-1993	1993-2003
GDP	+135%	-35%	+41%
PTB	+90%	-70%	+62%
DMC	+25%	-45%	-7%
DE	+22%	-46%	-11%
POP	+24%	+3%	+4%

Source: Own calculation

5.3. Material Backbone of the Physical Economy

The structure of the Cuban economy shows little diversification, based on the production and export of few raw materials (sugar cane and nickel) and highly dependent on energy imports (crude oil). This chapter highlights the detailed material flows of sugar cane, nickel and crude oil as three key aspects of the Cuban economy. An analysis of these materials on a more disaggregated level provides deeper insights into the development of the physical economy. Due to their high socio-economic importance as strategic raw materials and export commodities, the dimension and dynamics of the nickel and sugar cane flow will be analyzed in an economic-political context from 1970 to 2003. Finally, the structure of the Cuban energy system will be examined, focusing on fossil energy carriers and electricity.

5.3.1. Sugar Cane

Sugar cane is the most important primary crop commodity for the Cuban economy. The magnitude of the Cuban metabolism was highly determined by the huge amounts of extracted sugar cane, accounting for 40% of the total domestic extraction between 1970 and 2003 (Tab. 22). The amount of sugar cane as a share of biomass extraction accounted for 56%. Sugar exports made up 95% of the total biomass exports and 80% of all physical exports between 1970 and 2003. The high share of sugar exports and domestic extraction reflects the great importance of sugar cane compared to other crop commodities and emphasizes its high socio-economic value to the Cuban economy.

Tab. 22: Sugar Cane as a Share of Domestic Extraction

	1970	1980	1990	2003
Sugar Cane (% of DE)	54.4%	42.3%	45.3%	24.9%

Source: Own calculation

Figure 24 shows the development of sugar cane extraction in Cuba between 1970 and 2003.

Fig. 24: Domestic Extraction Sugar Cane

Source: FAO (2004)

Sugar cane traditionally has played an important role in the Cuban economy and foreign trade (Funes Monzote, 2004). The Cuban growth model between 1970 and 1989 focused on accelerated industrial development financed with the income generated by the sugar industry (Monreal, 2003). The choice of agriculture as a stimulant for industrialization was made considering the availability of land area, comparative advantage towards other sectors due to efficiency, know-how and short circles of maturation allowing quick revenues from short-term investments (Alvarez Gonzales, 1998). Contracts were signed with the former USSR that guaranteed the assured sale of 24.1 million tons of Cuban sugar between 1965 and 1970 at an agreed price of 6.11 USD cents per pound (Alvarez Gonzales, 1998).

In 1970, the production of sugar cane reached its historical peak (Alvarez Gonzales, 1998), amounting to 83 million tons or 10 t/cap/yr and accounting for 98% of the extracted biomass. There was a cut in the extraction of sugar cane in 1972, when it reached only 60% of the output produced in 1970. Declining export and production figures at that time went along with a reduction of the harvest area (-20%) and sugar yield (-30%). After 1972, sugar cane extraction recovered and increased steadily until it culminated again in 1979, reaching 77 million tons or 8 t/cap/yr.

Various factors stimulated sugar production. The entrance of the Cuban nation in the Council for Mutual Economic Assistance (COMECON) in 1972 allowed a beneficial integration in the Socialist division of labor. The COMECON countries represented large, secure and stable selling markets. Foreign trade relations between Cuba and other Socialist countries permitted granted sales at favorable conditions and assured prices lying above world prices (Alvarez Gonzales, 1998) and thus protected the economy against total exposure to the fluctuations in the world market. The five-year plans 1976-1980, 1980-1985, 1986-1990 helped in planning the economic output and setting productive goals. These and other factors could explain how it was possible to maintain sugar extraction at such a high level over an extended period of time. In that period sugar cane production stabilized at around 70 million to 80 million tons until it peaked in 1989. In 1989, the production of sugar cane corresponded to 1,260 times the production of corn and 170 times the production of rice.

A relatively high share of the permanent cropland in Cuba was dedicated to the production of sugar cane (1970-1989: 40%, 1993-2003: 25%). This had significant effects on the food supply in Cuba. Because most arable land was used for the production of sugar cane destined to export, large amounts of other important food crops (mainly cereals, e.g. wheat, rice and corn) had to be imported. Intensive land use based on massive inputs of fertilizers and herbicides in the Cuban agriculture throughout the 1980s was accompanied by growing sugar yield. Environmental pressures related to sugar production, e.g. erosion, poor soils and contamination of rivers are also characteristic for that period.

Cuba´s trade patterns and agriculture specialized in the production of sugar cane contributed to industrial and economic development between 1970 and 1989. The collapse of the Socialist community marked a radical point of change in socio-economic and environmental terms. It meant the total lack of foreign trade partners, the absence of loans and long-term contracts, and a complete loss of important export markets. These factors inter alia caused a severe loss in sugar cane extraction throughout the nineties. By the end of the Cold War, sugar cane production dropped from 82 million tons or 8 t/cap/yr produced in 1989 to 43 million tons or

4 t/cap/yr in 1993. In addition, falling world market prices (Mesa-Lago, 2005; Gaese, 2002) were not able to stimulate sugar production sufficiently. In 2003, sugar cane production amounted only to 22 million tons (2 t/cap/yr), which was less than a third compared to that of 1970 (Tab. 23).

Changes in both, sugar cane harvest area and yield reduced the production of sugar cane in that period. First, there was a considerable change in yield between 1989 and 2003. The sugar cane yield dropped more than half from 60t/ha in 1989 to 28t/ha in 1995. This efficiency loss was caused probably by decreasing inputs in agriculture. The import of fossil fuels, and the input of fertilizers and herbicides fell drastically during the 1990s, from 0.6 to 0.1 million tons (Tab. 22). On the other hand, sugar production figures correlated with the sugar harvest area. This means that decreasing extraction of sugar cane during the 1990s was also a direct consequence of the reduced harvest area, which declined from 1.4 mio. ha in 1990 to 0.7 mio. ha in 2003 (see Tab. 22). This was probably the response to falling sugar world prices and efficiency losses in agriculture as a consequence of fuel shortage and deficient fertilizer imports (see also Lippmann et al., 1997).

Tab. 23: Sugar Cane Indicators

	1970	1975	1980	1985	1990	1995	2000	2003
Absolut DE Sugar Cane (mio t.)	82.9	52.4	64.0	67.4	81.8	33.6	36.4	22.9
Per capita DE Sugar Cane (t/cap/yr)	9.7	5.6	6.6	6.7	7.7	3.0	3.3	2.0
Share of Sugar Cane of Total DE (%)	54.5	40.9	42.3	40.6	45.3	34.4	33.3	24.8
DMC Sugar Cane (t/cap/yr)	8.8	5.0	5.9	6.0	7.0	2.8	2.9	1.8
Sugar Exports (mio t)	7.8	6.1	6.7	7.1	7.6	2.7	3.6	1.9
Share of Sugar Exports of Biomass Exports (%)	99.0	98.0	95.4	91.8	93.4	96.4	96.0	95.5
Harvest Area (mio. ha)	1.5	1.2	1.4	1.4	1.4	1.2	1.0	0.7
Sugar Cane Harvest Area as a Share of Agricultural Area(%)	29.8	20.3	23.4	21.7	20.4	17.0	14.6	9.8
Sugar Yield (t/ha)	55.4	44.3	46.0	50.0	57.6	28.5	34.9	35.0
Fertilizer Input (Production+Import) (mio t)	0.4	0.4	0.5	0.7	0.6	0.3	0.1	0.1

Source: Own calculation based on FAO (2004)

5.3.1.1. Use of sugar cane crop residues and industrial sugar by-products

Extensive sugar cane production as practiced in Cuba brings about the production of huge amounts of residues and by-products. Sugar cane residues and by-products represent a relatively large flow, quite significant to the Cuban economy due to their relatively high socio-economic value and low-cost benefits. In Cuba, special attention has been given to the research of sugar cane by-products and crop residues (Quiroz et al., 1997 and Aguilera Corrales et al., 2005) and their incorporation in the sugar production process itself (Perez, 1992 and Valdes Delgado et. al, 2001). Sugar cane crop residues and by-products can contribute to increasing the economic value-added to sugar production (e.g. reduce fossil fuel consumption, water use and chemical fertilizer inputs) and have great potential for the application of organic technologies (wastewater for irrigation, straw coverage to decrease weed formation, sowing in contour to reduce erosion, compost, ashes and filter cake to fertilize soil).

Residuals obtained from sugar cane production are divided into *crop residues* produced at harvest (residues produced at the agricultural stage of raw sugar cane production that remain on the field, e.g. straw, leaves used as animal feed, herbicides and substitutes for fossil fuel) and *by-products* obtained from industrial sugar processing (residues produced at the industrial stage during sugar production, e.g. bagasse, molasses, ashes, filter cake).

Sugar cane crop residues play a vital role in Cuban farming and feeding systems. In total, residues account for 42% of the total sugar cane biomass production. Out of this fraction around 90% are used further. It is assumed that 66% of the residues used are made available for animal feeding. The production of sugar crop residues of course is closely linked to the production of sugar cane. Therefore the residues production curve shows similar trends as sugar extraction (Fig. 25). Between 1970 and 2003 approximately 95% of total crop residues produced in Cuba came from the cultivation of sugar cane. During the 1990s, the production of crop residues dropped simultaneously corresponding to the falling production of sugar cane.

Fig. 25: Used Crop Residues

Source: Own calculation based on FAO (2004)

Sugar cane crop residues comprise the fraction of residues that is produced at the harvest and left on the field, e.g. straw and leaves. Sugar crop residues can be further used as animal feed, herbicides and as substitutes for fossil fuels (Tab. 24). Mainly fibrous crop residues, e.g. cane tops, green and dry leaves, pressed stalk, chopped whole or derinded sugar cane are used as cattle feed (Preston, 1995).

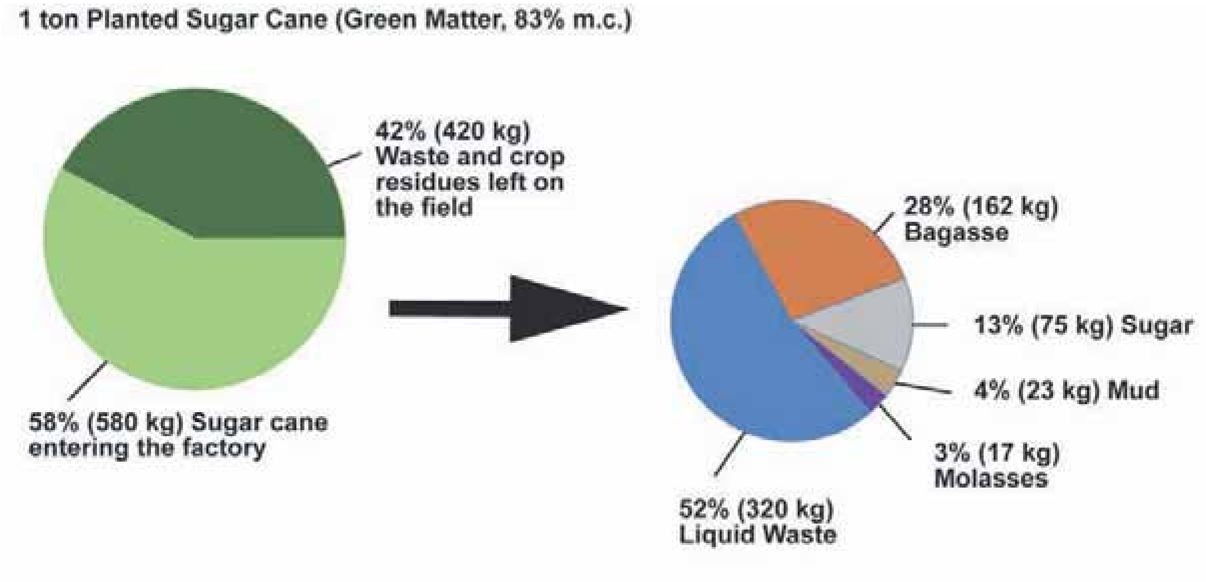
Tab. 24: Use of Sugar Cane Residues

Form	Use	Environmental Effect
Cut	Steam Generation for • Manufacturing • Electricity Production	Substitution for fuel oil
Densified	Cooking	Substitution for firewood, charcoal, gas oil or kerosene
Cut or Natural	Animal feed	Substitution for market feed
Natural	Soil coverage	Substitution for herbicides and to maintain soil humidity

Source: Valdes Delgado et. al, (2001)

By-products originate from industrial sugar processing and comprise residues produced at the industrial stage of sugar production, e.g. bagasse, molasses, ashes, filter cake (Fig. 26).

Fig. 26: Production of Sugar Cane By-Products



Source: Almazan et al. (1998), modified

Final molasses and cane juice are used for the production of alcohol, paper and animal feed. Molasses are mostly fed to non-grazers due to their high energy value and high digestibility. Molasses, syrups and concentrated juice are broadly used for pig feeding. Between 1970 and 1989 cane juice, syrups (Valdes Delgado et. al, 2001) and "C" molasses mixed with Peruvian fishmeal (Preston, 1995) were also used as cattle feed in Cuba. More recently dried sugar cane leaf meal mixed with "B" molasses is used as chicken feed (Preston, 1995).

Bagasse is similar to soft wood, consisting of fibre, pith, non-soluble solids and water. It represents a valuable raw material for fuel and energy production. In Cuba 90% to 92% of the produced bagasse are used for the generation of electrical power for the sugar industry (Valdes Delgado et al. 2001). After chemical and mechanical treatment, bagasse is also used as animal feed and for the production of pulp, paper, particle and fibre boards (Almazan et al., 1998). Particularly the bagacillo treated with sodium hydroxide and some fraction of pith are used for cattle feeding (Preston, 1995).

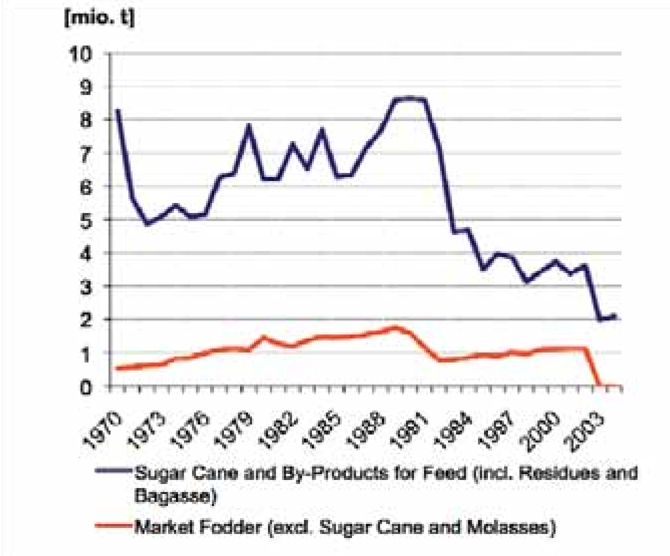
Filter cake, which contains nitrogen, phosphorus, potassium and organic matter, can be used in the production of organic and mineral ferilizers, and in the production of animal feed, biogas, compost and wax (Valdes Delgado et al. 2001).

Compost, which is produced from crop resides, filter cake, bagasse, distillery residuals, animal manure and other organic matter, facilitates the fixation of nitrogen from the air, water retention, return of soil nutrients and increases the action of inorganic fertilizers (Valdes Delgado et al. 2001).

Biogas, produced from a mixture of residual water and filter cake, results from a decomposition of these components under anaerobic conditions. Biogas is used for the generation of electric energy and as a substitute of fossil fuels in households and industrial processes; mud resultant from biogas production can be used as organic fertilizer (Valdes Delgado et. al, 2001). The use of biogas reduces deforestation, soil erosion and the emission of greenhouse gases. The use of waste waters for irrigation purposes, after cooling and cleaning, reduces water consumption.

Figure 27 shows the role of sugar cane residues and by-products for animal feeding in Cuba.

Fig. 27: Sugar and Non-Sugar Animal Feed



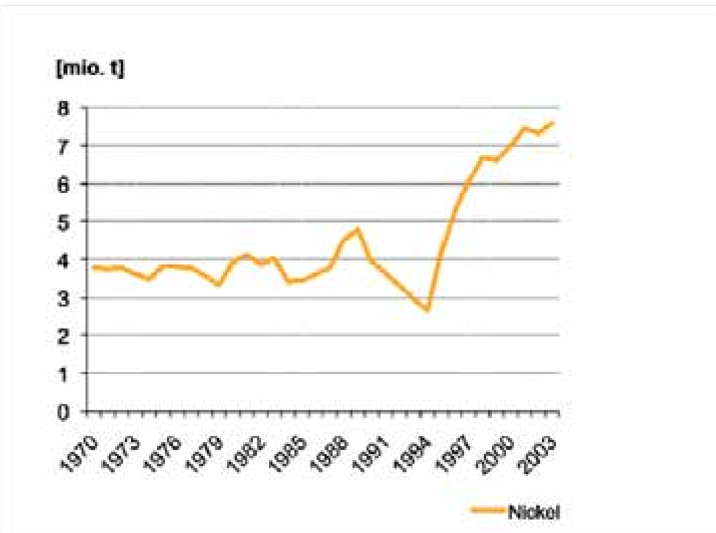
Source: Own calculation based on FAO (2004)

Usually the DMC of raw material exporting countries, many of which are developing countries, is high, because wastes and residues remain in the country. In most cases, so-called wastes offer great possibilities for recycling, and if adequately treated, have a positive environmental and economic impact. In the case of Cuba, crop residues and by-products of the sugar cane industry are broadly reused as industrial and agricultural raw materials, e.g. for the production of energy, paper, boards, herbicides, fertilizers and animal feed.

5.3.2. Nickel

Although nickel gross ore production represents a minor fraction of the total domestic extraction (1970-1989: 2.5%; 1993-2003: 5.6%), it is an important mineral and export commodity for Cuba and from a global perspective. Cuba possesses the third largest nickel reserves in the world, amounting to 800 million tons of proven nickel and cobalt reserves (Reuters, 2008; Österreichisch Kubanische Gesellschaft, 2008) accounting for 34% to 38% of the world´s known nickel ore reserves. (Rabchevsky, 1994; Reuters, 2008). Nickel ore, which in Cuba mainly appears in lateritic deposits (Ashok et al., 2004), is currently mined in three mines in Punta Gorda, Nicaro and Moa Bay. Cuba, being the 6th largest producer of nickel (Villanueva, 2000), produced an average of 4.5 million tons nickel gross ore/yr between 1970 and 2003 (Fig. 28).

Fig. 28: Domestic Extraction Nickel



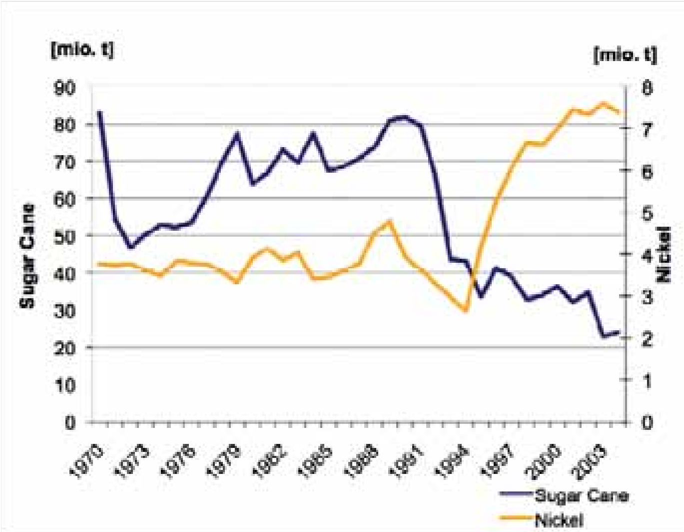
Source: United Nations Industrial Commodity Statistics Database (2004) and USGS (2006)

The average annual extraction of nickel gross ores between 1970 and 1989 amounted to 3.7 million tons/yr during the 1970s and increased only slightly in the first half of the 1980s to 4 million tons/yr on average. The stable amounts of extracted nickel ore on a relatively high level in that period (88% of DE ores) was due to efficiency and productivity gains thanks to rising investments and economic assistance. Outdated facilities of the nickel industry constructed prior to 1959 with North American capital, were rehabilitated, modernized and upgraded in collaboration with the USSR. In the 1980s, two plants were constructed in Las Camariocas and in Punta Gorda in cooperation with the former USSR and the Council of Mutual Economic Assistance. (Alvarez Gonzales, 1998). These investments had an impact on rising production volumes. Between 1985 and 1989 alone, the production of nickel gross ore grew 30% from 3.5 million tons 1985 to 4.5 million tons (1988).

During the economic crisis in the early 1990s nickel extraction saw dramatic losses. It declined by 45% between 1989 and 1993. In the same period the annual production of nickel fell from 4.8 million tons gross ore in 1989 to 2.6 million tons produced in 1994. These losses in output were mainly due to lacking investments, maintenance problems, a change of the refinery personnel, shortages of electrical energy, a lack of fuel, machinery spare parts and chemical reagents between 1989 and 1993 (Ashok et al., 2004 and Rabchevsky, 1994). Changing patterns of trade, the absence of subsidies, the loss of former foreign trading partners and important export markets also caused disruptions in the extraction of nickel after 1989, since nickel production and export were closely connected. Prior to 1989, some 73% of the total nickel exports had been absorbed by the COMECON market (Álvarez Gonzáles, 1995). Nickel exports broke down somewhat delayed in 1994, minus 97% compared to 1993. Until then nickel exports were artificially inflated by a rundown of stocks accumulated in the late 1980s (Rabchevsky, 1994).

In Cuba basic industry still is a leading sector in the generation of income. Seeking the re-integration into the world market in the 1990s, nickel represented a strategic raw material and replaced sugar in its significance as top export commodity and a major source of foreign currency (Fig. 29).

Fig. 29: Nickel and Sugar Cane



Source: FAO (2004) and USGS (2006)

Between 1994 and 1996 nickel extraction doubled, increasing outputs from 2.6 to 5.3 million tons gross ore per year (Tab. 25). Between 1993 and 2003 the average annual growth rate of nickel extraction was 9%. Increased nickel extraction in that period had various causes**.** In 1993, in response to the collapse of the Socialist market and to attract foreign investments, a significant change of the 1976 constitution recognized private property, foreign investment and ownership in joint venture deals (Rabchevsky, 1994). The new Mining Act of 1994 (Law No. 76) and the Foreign Investment Act launched in 1995 (Law No. 77) facilitated further investment by international corporations, opening all sectors to foreign investment and allowing also full participation of foreign capital even without Cuban partners (Alvarez Gonzales, 1995; Torres, 1995). Growing demand and relatively high world prices for nickel in the past years (International Nickel Study Group, 2008) have attracted foreign capital and in turn stimulated production. In 1994, the state-run Compania General de Niquel S.A. formed a joint venture with the Canadian Sherritt Inc. including mineral concessions and 50% of the Moa assets (Torres, 1995). In 2004, China signed 16 agreements that included investments over USD 500 million in the completion of the abandoned ferronickel plant in Las Camariocas and the establishment of a joint venture holding 49%. Cuba in turn granted the supply of 4,000t/yr of nickel from 2005 to 2009 (Bermudez Lugo, 2004).

Foreign investments surely helped to boost nickel production, upgrade plants and to overcome maintenance problems. However, it is necessary to examine the legal character and structure of these contracts in order to evaluate their impact on Cuban physical economy and its material flows. Further studies need to be conducted on issues related to foreign direct investment and privatization, e.g. high mobility of business activities, free transference abroad of net profits or dividends, tax reduction, decreasing public revenues, indefeasibility, short term profit orientation at the expense of environment protection measures, salaries and wages (Becker et al., 2003).

Nickel mining is associated with considerable environmental pressures. Two principal hydrometallurgical operations are employed in Cuba for the treatment of nickel laterites. At the Nicaro and Punta Gorda plants the Caron process is applied using atmospheric ammonia leaching of reduced nickel in order to obtain nickel-oxide sinter; Pressure Acid Leach (PAL) is used in the Moa plant in order to obtain mixed nickel-cobalt sulfide (Ashok et al., 2004). One of the most polluting processes in Cuba is the reduction-ammonia leaching process used at the Nicaro and Punta Gorda plants releasing extensive dust emissions. Hydrogen sulfide acid used in the Moa plant to precipitate nickel and cobalt at present is disposed as untreated. Its gas has also a high solubility in water and is highly corrosive (Rabchevsky, 1994). Health hazards and environmental contamination caused by chemical reagents and metal wastes related to nickel and cobalt recovery need to be further examined.

Tab. 25: Nickel Indicators

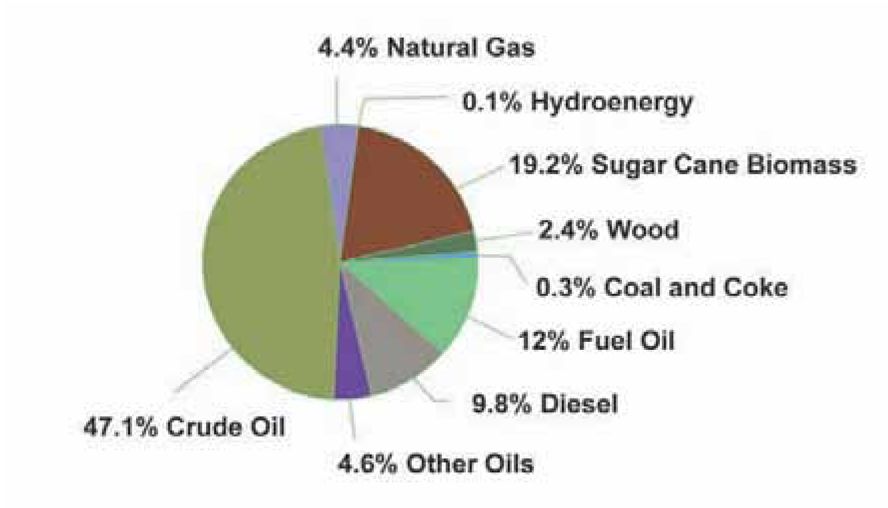
	1970	1975	1980	1985	1990	1995	2000	2004
Absolute DE Nickel (mio t. gross ore)	3.78	3.83	3.92	3.45	3.9	4.19	6.99	7.6
Absolute DE Nickel (mio t. net ore)	0.036	0.037	0.038	0.034	0.038	0.040	0.068	0.074
Per capita DE Nickel (t/cap/yr)	0.44	0.41	0.40	0.34	0.37	0.38	0.62	0.65
Share of Nickel of total DE (%)	2.48	2.99	2.59	2.08	2.18	4.29	6.40	8.26
Share of Nickel of DE Ores (%)	95.19	89.84	88.51	83.32	86.18	85.41	82.78	91.59
Nickel Exports (mio. t)	0.035	0.031	0.038	0.032	0.303	0.008	0.126	0.12

Source: Own calculation

5.3.3. Fossil Fuels and the Cuban Energy System

According to Perez et al. (2005), in 2002 Cuba's energy supply was dominated by 78.2 % of fossil fuels (47.1% crude oil, 26.4% diesel, fuel and other oils, and 4.4% associated gas), 19.2% from sugar cane biomass and 2.4% from wood. Coal and coke (0.3%), and other energy sources (0.02%) are of minor importance. In 2002, windmills, biogas, hydraulic systems, photovoltaic and wind systems contributed 0.22% of the total energy supply. In electricity generation, fossil fuels were predominant (93.3%), while the use of renewable resources was limited to 6.7% in 2002 (Fig. 30).

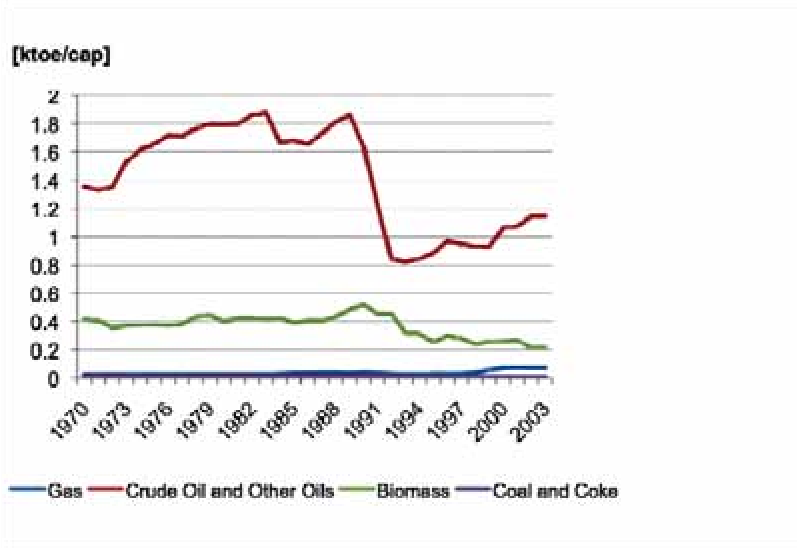
Fig. 30: Total Primary Energy Supply 2002



Source: Perez et al. (2005)

Figure 31 shows the total domestic energy supply by energy carrier between 1970 and 2003. The total energy supply increased during the 1970s and 1980s by 60% in accordance with the energy-intensive development in social, economic and industrial terms. The energy crisis in the early 1990s resulted in a decline of the domestic energy supply. After economic recovery in the mid-1990s total energy supply did not increase and remained below the level of the 1970-1989 period. Mainly industry was affected by energy savings, while the household and service sectors recovered more rapidly. In 2003, the primary energy supply of biomass and fossil fuels was lower than in 1970, while the production of natural gas and electricity increased.

Fig. 31: Domestic Energy Supply by Energy Carrier



Source: IEA (2002)

The energy use by sector changed after 1989 due to structural changes in the domestic economy: away from the export-oriented agricultural and industrial development model of the 1970s and 1980s towards a service-based economic policy. These changes resulted in lower overall energy use in industry and agriculture and higher energy use in low energy sectors (services, households and transportation) (see Tab. 26). The growing energy use in the service sector is in particular related to the increase of tourism since 1995. However, like in most economies, the major share in energy use is found in industrial sectors (mainly steel, nickel, sugar cane, cement, construction materials, food) (Perez et al., 2005).

Tab. 26: Energy Use by Sector

	1970	2002
Industry	76.0	64.1
Transport	6.6	9.3
Services	10.2	14.0
Household	7.2	12.6

Source: Perez et al. (2005)

5.3.3.1. Fossil Energy Carriers

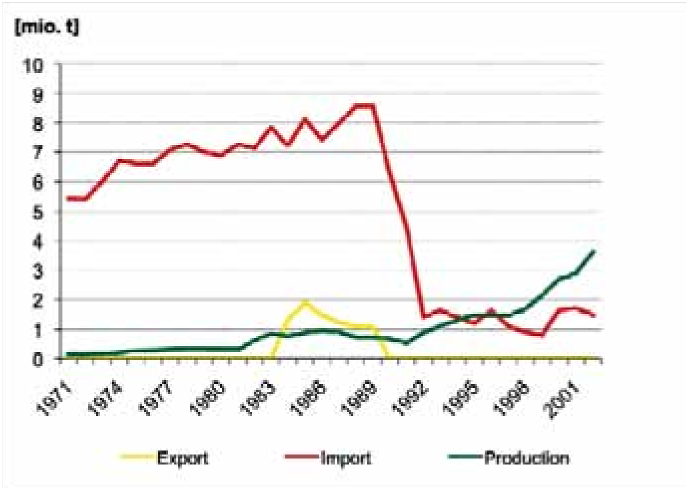
What is remarkable about the Cuban energy system is that it is almost entirely based on imported fossil fuel and some energy recovery from sugar cane by-products. High oil imports along with low domestic extraction and low exports illustrate the high degree of external dependence on fossil energy imports, which is, in such a way, characteristic for Cuba. Very interesting is the absence of coal as an energy carrier within the Cuban energy system.

Between 1970 and 1989 oil imports increased from 7.6 to 14 million tons/yr, due to accelerated industrial and economic development in that period, when there were safe and stable amounts purchased from the former Soviet Union at preferential prices (Perez et al., 2005). Between 1989 and 1993 fossil fuel imports dropped more than half from 14 million tons to 6.5 million tons (Fig. 32).

The economic crisis and changing patterns of trade during the 1990s triggered a structural change of the energy system. There were various economic and political reasons for collapsing crude oil imports between 1989 and 1993: the collapse of the former USSR, the loss of long-term trade agreements and trading partners, and a lack of financial support and foreign currency forced Cuba to reduce its fossil energy imports. There were two basic approaches to encounter energy shortages; one was to increase the domestic extraction of crude oil, the other focused on energy recovery from sugar cane residues and by-products.

The National Energy Sources Development Program of 1993 aimed at progressively reducing energy imports by increasing the domestic extraction of crude oil and natural gas for electricity generation and promoting a more efficient use of bagasse and sugarcane residues for energy production (Perez et al., 2005). Consequently, in the 1990s crude oil imports decreased diametrically as domestic extraction of crude oil and gas increased. That shows how from then on oil demand was increasingly covered by domestic crude oil extraction rather than oil imports. This trend reflects the efforts of the Cuban Government to substitute oil imports to face the energy crisis of the early nineties. Despite this, the DE of crude oil could not compensate for the reduced oil imports. Consequently the domestic energy supply declined after 1989, resulting in energy shortage.

Fig. 32: Oil Trade and Domestic Extraction



Source: IEA (2002)

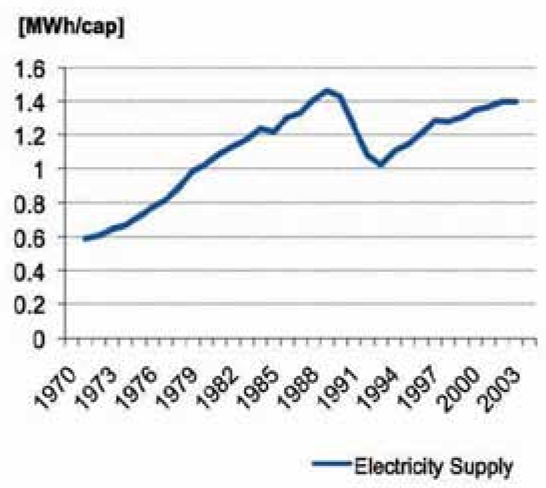
There was a major shift in the structure of the Cuban energy system after 1989. The strategy was to secure the domestic oil supply by reducing expensive energy imports and increasing domestic oil extraction with the aid of foreign direct investment in the petroleum sector. In order to overcome decapitalization, foreign direct investment was needed for the exploitation of existing wells and the exploration for new deposits. In the early nineties, international oil companies from Canada, France, Sweden, Brazil, Spain and the U.K explored in Cuba (Perez et al., 2005; Villanueva, 2000). In 2004, 174 petroleum wells were in production, 170 of which are located in Matanzas region, east of Havana (Bermudez Lugo, 2004). The production of crude oil between 1993 and 2003 could be increased mainly due to foreign investments, modernization and the use of more efficient technology, e.g. horizontal perforation and modern pumping system (Villanueva, 2000). However, the great participation of foreign oil companies in the Cuban energy sector represents a new form of external dependency on foreign capital.

5.3.3.2. Electricity

The production of electrical power is not subject to this MFA, nevertheless it provides information on the structure of the energy system of a physical economy, e.g. the electricity supply of society and the use of fossil fuels and sugar cane biomass for electricity production. I will give a few structural descriptions of the Cuban electricity sector, principal energy sources and electricity generation.

Between 1970 and 1989 per capita electricity supply increased by 150% from 5,000 GWh (0.6 MWh/cap) to 15,240 GWh (1.5 MWh/cap) in accordance with the energy-intensive economic and social development of the country in this period. During the energy crisis in the early 1990s electricity production fell abruptly to 11,000 GWh or 1 MWh/cap (1993) and recovered in the mid 1990s, so that by 2003 it reached the level of 1989. Overall electricity supply tripled between 1970 and 2003 (Fig. 33). However, from a global perspective current per capita energy consumption in Cuba is quite low.

Fig. 33: Per-Capita Electricity Supply



Source: IEA (2002)

In the 1970 – 1989 period electricity consumption by sector remained quite stable (Industry 50%, Agriculture 4%, Services 18%, Households 26%) (Fig. 34). After 1989 electricity use dropped in all sectors. Mainly facilities of the industrial, agricultural and service sectors were affected by energy shortages. Many industries were closed due to a lack of fuels and electrical power. Supply constraints and blackouts were common and occurred daily at that time. In general, households were less affected by energy shortages, because social goals were prioritized (Perez et al., 2005). Between 1989 and 1993 a structural change of electricity consumption patterns by sector occurred (Industry -20%, Agriculture -50%, Services +25%, Households +30%).

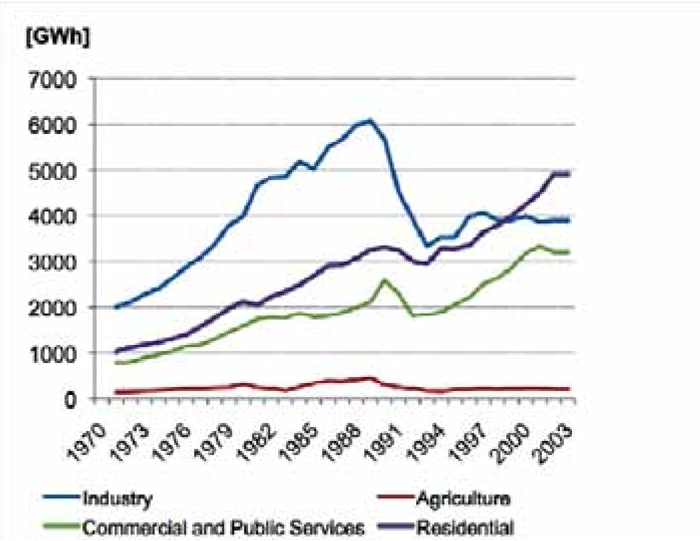
Fig. 34: Share of Electricity Consumption by Sector

	1970	1989	2003
Industry	50.1%	51.1%	31.9%
Agriculture	3.6%	3.8%	1.6%
Commercial and Public Services	19.6%	17.7%	26.2%
Residential	25.9%	27.3%	40.3%

Source: IEA (2002)

In the period of economic recovery after 1993, electricity use in services and households grew at a greater speed than in the industrial sector (Fig. 35).

Fig. 35: Electricity Consumption by Sector



Source: IEA (2002)

Electricity demand growth in households was limited due to restrictions imposed on purchasing new high-consumption electric appliances and the introduction of a new tariff system, e.g. increased and staged electrical tariffs for households and non-household sectors based on voltage levels, schedule of use and type of consumer. The implementation of the Cuban Electricity Conservation Program, subsidized programs (distribution of energy-saving bulbs; replacement of households' refrigerator door gaskets) and energy conservation information campaigns (educational programs, advertisements and promotional videos) achieved adjustments (i.e., outside peak hours) and reductions in demand after 1997 (Perez et al., 2005).

Between 1970 and 2003 the role of fossil fuels for electricity generation increased from 80% to 95%. In the same period the share of sugar cane biomass fell from 18% to 4.6% in accordance with decreasing sugar production, the share of hydro and wind power fell below 1% (Tab. 27).

Tab. 27: Energy Sources for Electricity Production

	1970	2002
Oil	80%	86%
Gas	-	9.1%
Biomass	18.0%	4.6%
Hydro and Wind	1.9%	0.8%

Source: Perez et al. (2005)

Most electrical power generated in Cuba between 1970 and 2003 was produced by thermal power plants and by heat and power plants of the sugarcane industry. The use of crude oil in thermal power plants, many of which were designed to run with fuel oil, caused massive efficiency losses during the energy crisis of the nineties (Perez et al., 2005). Adaptations of thermal power plants in order to use domestic crude oil and the incremental use of associated gas in gas turbines for electricity generation, increased energy efficiency and lowered fuel use in electricity generation in the late 1990s (Perez et al., 2005).

In the 1990s alternative sources for electricity generation started to be used. In 2002, 169 hydroelectric power plants, 6767 windmills for water pumping, 139 biogas digesters, 7 wind generators and 45 hydraulic ram pumps were in operation (Perez et al., 2005). However, these renewable energy sources play only a minor role in the generation of electricity (< 1%). Currently no nuclear energy is used in Cuba.

6. Sustainable Development

This chapter analyzes human development in Cuba between 1970 and 2003, evaluating the material flow indicators DE and DMC in relation to the HDI and the ecological footprint in a global context.

6.1. Human Development

The HDI was taken as an indicator for measuring aspects of overall life standard and wellbeing. It combines measures of life expectancy, school enrollment, literacy and income, and allows a broader view of a country's development rather than using GDP alone.

The Cuban human development index is 0.838 (UNDP, 2007). Thus, Cuba is in the range of most high-income nations. Between 1970 and 2003 Cuba achieved especially high scores in the education and longevity indices (>0.8) at a medium scale income index (0.6-0.8) (Tab. 28).

Tab. 28: Human Development and Partial Indices

	1970	1975	1980	1985	1990	1995	2000	2003
Life Expectancy Index	0.753	0.802	0.817	0.827	0.828	0.834	0.850	0.860
Adult Literacy Rate	0.973	0.978	0.983	0.988	0.991	0.995	0.999	1.000
Gross Enrollment rate	0.866	0.870	0.874	0.879	0.881	0.878	0.881	0.881
Education Index	0.938	0.942	0.947	0.951	0.954	0.956	0.959	0.960
Income Index	0.635	0.653	0.672	0.734	0.724	0.657	0.691	0.701
HDI Cuba	0.775	0.799	0.812	0.837	0.835	0.815	0.833	0.840

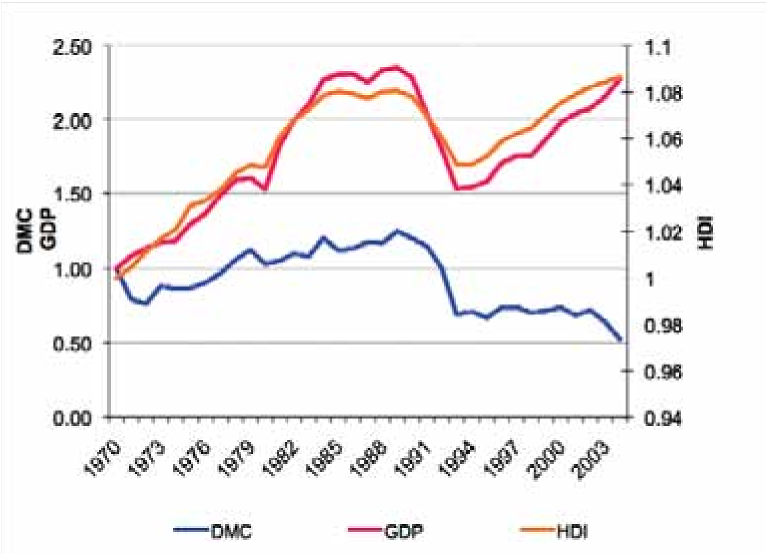
Source: Own calculation

The education index, measuring gross enrollment and adult literacy, lies above average. The literacy rate of Cuba compared to other industrialized nations is either same or higher (Cuba: 99.8%; High-Income OECD: 99.1%). Life expectancy in Cuba (77.7 years) is higher than in the rest of Latin America and the Caribbean (72.8 years) rather comparable to high-income nations (U.S.: 77.9 years) (UNDP, 2007).

It is remarkable that despite poor economic performance, affected by periodical supply bottlenecks, a severe financial crisis and a trade embargo, Cuba features high human development. These achievements are above all the result of a widespread welfare regime, which ensures all-embracing social services for the entire population. Free health care and educational system as well as general child care, an old age pension scheme, unemployment support and facilities for a reasonable livelihood (Bertelsmann-Stiftung 2003) have without any doubt positively influenced the education and life expectancy index.

Due to its good overall performance in these categories, the HDI directly reflects the GDP's trend, indicating that despite high HDI, human development in Cuba was strongly influenced by economic growth (Fig. 36). That also shows how strong the human development concept is based on economic parameters.

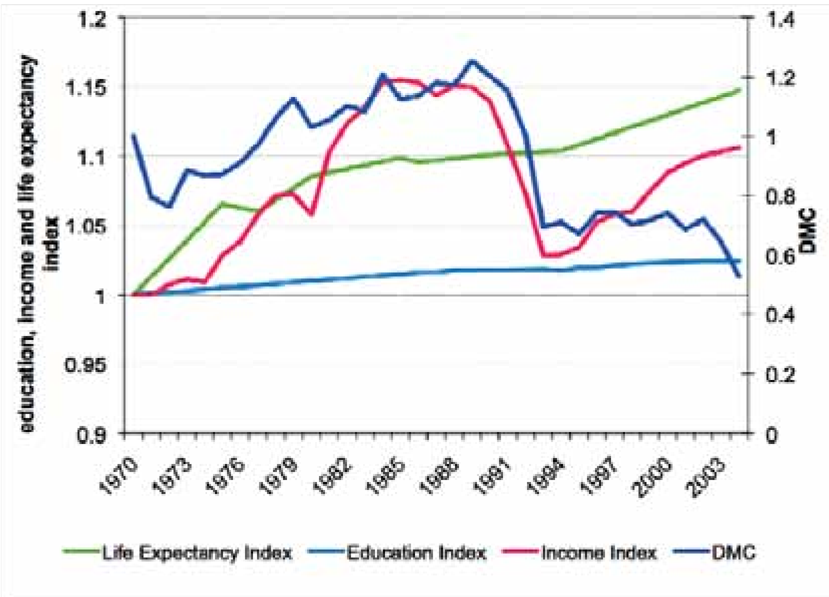
Fig. 36: DMC, GDP and HDI



Source: Own calculation

Since the HDI reflects the development of the GDP, the same applies for the relation of HDI and DMC as for the relationship of GDP and DMC. It evidences the interlinkage of material flows, human development and economic growth. An analysis of the health care and educational partial indices, however, yields a different result (Fig. 37). The health care sector and the educational system developed quite independently from income and material consumption. School enrollment and literacy standards moved forward on a continuously high level. Overall life expectancy even increased in these thirty years.

Fig. 37: Human Development Indicators and Domestic Material Consumption



Source: Own calculation

Whilst human development and economic growth during the 1970s and 1980s by comparison are closely connected with material use, an intensified absolute decoupling of material consumption and human development took place from the 1990s onwards.

6.2. International Comparison

In a study published by Moran et al. (2008) two different indicators were brought together for measuring sustainable development. The HDI was used for measuring overall dimensions of human development and wellbeing, and the ecological footprint was used as an indicator for sustainable consumption (Moran et al., 2008). According to this study, Cuba is the only country that met both criteria for sustainable development with a HDI greater than 0.8 and a footprint to biocapacity ratio lower than 1 earth equivalent; it is one out of 33 countries with an HDI greater than 0.8 that decreased its ecological footprint to biocapacity ratio between 1975 and 2003, while all other high-income countries showed the opposite trend (Moran et al., 2008). Thus, according to these criteria, Cuba is the only country surveyed that can be considered sustainable with a consumption pattern that could be expanded globally without overstressing the regenerative capacity of the planet.

According to the ecological footprint Cuba is sustainable, according to the HDI it features high human development. On the other hand low national income and material consumption (low GDP and low DMC) indicate poor economic and material status, especially after the collapse in 1989. In the case of Cuba, the low ecological footprint is mainly the result of low fossil fuel consumption. Thus, the low EF and DMC after 1989 had less to do with sustainable development than with the collapsing economy and is, just as the MFA showed, mainly linked to low availability of energy and the strong decrease of material consumption.

The decreasing footprint to biocapacity ratio in Cuba between 1975 and 2003 reflects the trend of declining material intensity, which decreased from 11.5 kg/USD to 3.5 kg/ USD in the same period of time. Rapidly declining material consumption and material intensity after 1989 were mainly the expression of material shortage, caused by an economic crisis and supply bottlenecks, indicating considerable pressures on the Cuban population. In addition, an economic embargo does not allow the compensation of the naturally limited capacity of resources through trade, which complicates the supply with food and raw materials.

In this context, the question arises in how far declining/stagnant DMC along with increasing GDP affected the well-being of the Cuban society, and whether the HDI and ecological footprint are appropriate measures for indicating standard of living and sustainability, because these indicators do not take into account social and political issues associated with individual rights, e.g. personal freedom, political participation, self-determination, decision-making processes, realization opportunities, earning capabilities or inequalities. Probably quality of life was adversely affected in the period after 1989 due to limited access to some basic services, e.g. restricted access to electricity and energy, and limited availability of consumer goods especially in rural areas, etc.

Table 29 lists MFA derived indicators, HDI and ecological footprint in a country comparison with Mexico.

Material productivity is higher in Mexico than in Cuba (by factor 2). That shows that less resources were needed in Mexico for generating one unit of GDP. In terms of capita, domestic extraction and material consumption are higher in Mexico than in Cuba (DE by 27%, DMC by 17%), whereas DE and DMC per unit of land area are higher in Cuba (DE by 28%, DMC by 45%). Although per capita material consumption is lower in Cuba, the DMC per land unit, taken as a pressure indicator, indicates comparatively high pressures on the natural environment.

The ecological footprint is 40% smaller in Cuba than in Mexico, the footprint of which amounts to 2.6 gha/cap and thus lies above the globally available biocapacity.

Tab. 29: HDI, Ecological Footprint and Mass Indicators

Indicator	Unit	Cuba	Mexico
HDI **	Index	0.838	0.829
DE*	t/cap/yr	8.2	11.2
	t/ha	8.4	6.0
DMC*	t/cap/yr	8.9	10.7
	t/ha	9.1	5.0
Material Intensity*	kg/USD	3.5	1.9
Ecological Footprint*	gha/cap	1.5	2.6
Biocapacity*	gha/cap	0.9	1.7
Footprint to Global Biocapacity Ratio*	earth equivalent(s)	0.8	1.4

*2003 **2005

Source: Moran et al. (2008), WWF (2006), UNDP (2007), Gonzalez-Martinez, A.C., Schandl, H. (2008)

Although Cuba’s ecological footprint amounts to 1.5 gha/person (2003) and thus lies beneath the globally available biocapacity of 1.8 gha/cap, it exceeds its own resource capacity since in theory only 0.9 gha/cap are available for securing Cuba´s consumption (Living Planet Report, 2006). This image also reflects the relatively high level of domestic material consumption and domestic extraction on an international scale. High material consumption, which is above all determined by extensive sugar cane production points to Cuba’s traditional specialization in export-oriented and material intensive sectors of the extractive industry.

7. Summary

The Cuban physical economy is specialized in the production of agricultural and mineral raw materials destined for export, mainly sugar cane and nickel. In terms of mass weight nickel ores are of minor importance, whereas sugar cane substantially determined the Cuban metabolism, comprising 56% of biomass extraction and 95% of all biomass exports between 1970 and 2003. Thus, biomass dominated the material balance, accounting for 70% of domestic extraction and for 60%-90% of all physical exports between 1970 and 2003. On the input side, Cuba is highly dependent on fossil fuel imports, mainly crude oil and oil products, comprising 70% of all physical imports.

The development of the Cuban physical economy follows the flow of a sinus curve and is divided in three phases: growth (1970-1989), collapse (1989-1993), recovery (1993-2003). Most material flows, economic and biophysical indicators follow these phases: HDI, GDP, DMC, DE and PTB, feature dynamic growth and a high level (1970-1989), and medium growth at an overall lower level (1993-2003) after the collapse in 1989.

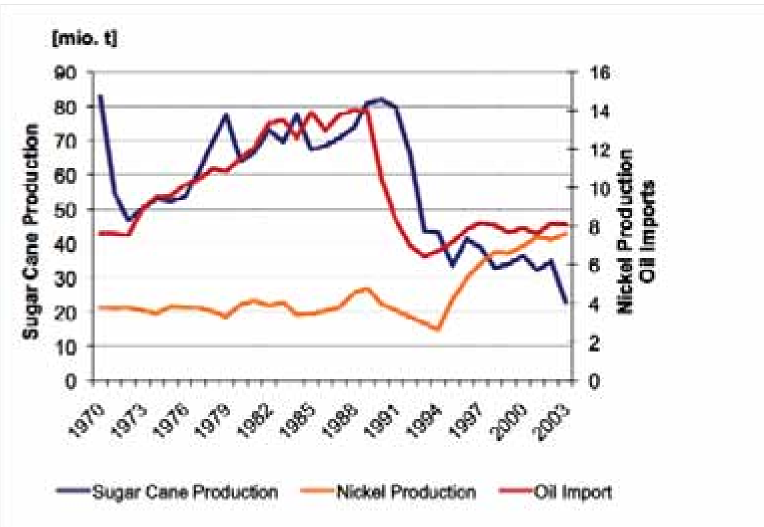
DE and DMC are strongly influenced by large amounts of extracted biomass (70%) and construction minerals (20%). While the DMC correlates with GDP during the period of growth (1970-1989), increasing decoupling of material use and economic growth is observed from the period of 1993 to 2003. Material intensity is constantly declining due to relative dematerialization between 1970 and 2003. The dynamics and dimension of PTB is strongly influenced by fossil fuel imports and less by sugar exports.

Accelerated social, economic and industrial development in conjunction with massive crude oil imports and huge amounts of extracted sugar cane is significant for the 1970-1989 period. The development strategy of the 1970s and the 1980s focused on material intensive activities for financing development. Sugar exports which generated income prior to 1989, were in part traded off directly against crude oil with the former USSR (Lippmann et al., 1997). The USSR trade relations had direct consequences on the physical economy. The membership in COMECON, financial support and investments in the basic industry encouraged an industrial/ agricultural development strategy based on the export of nickel and sugar cane. Intensive land use and high inputs of energy fuels, pesticides and fertilizers and associated environmental pressures are typical in that period.

The economic/biophysical collapse in 1989 marked a radical point of change in socio-economic and environmental terms and introduced a phase of reorientation. The collapse of the former USSR meant a loss of important trading partners and export markets, the absence of credits, investments and long-term contracts. The economic crisis in the early 1990s affected the development of most material flows, economic and physical indicators. It provoked a structural change in the metabolic profile and the energy system of the Cuban physical economy.

Sugar cane extraction and crude oil imports were reduced, while the domestic extraction of nickel doubled after 1989 (Fig. 38). Declining sugar cane production in the 1993-2003 period was the result of both, reduced harvest area and reduced sugar yield as a consequence of efficiency losses, energy shortages, lacking investments and declining inputs in agriculture. Nickel extraction, most of which is destined for export increased significantly from the mid 1990s mainly due to rising liberalization and foreign investments. Crude oil imports declined sharply after 1989 in favour of growing domestic extraction of crude oil with the aid of foreign direct investment and increased energy recovery from sugar cane by-products. The Cuban development scheme after 1989 focused on commercial opening and foreign investments in the petroleum and nickel industry in order to overcome maintenance problems and energy shortages. Issues relating to the domestic extraction of nickel and crude oil, the effect of foreign direct investments, environmental contamination and health hazards need to be further examined.

Fig. 38: Nickel, Sugar Cane and Oil



Source: Own calculation based on FAO (2004), IEA (2002) and USGS (2006)

Before 1989 sugar was Cuba´s strategic export commodity, followed by nickel. After 1989, tourism replaced sugar cane as the principal source of foreign currency. Tourism created an internal market of foreign currency attracting investments for modernizing and restructuring segments of the nickel industry (Monreal, 2003). Nickel substituted sugar cane as the most important income generating raw material. Currently nickel is Cuba´s largest export earner. In 2007, the revenues generated by the nickel industry surpassed tourism as a major source of foreign currency (Washington Post, 2008). In the nineties, tourism, nickel, sugar and family remittances became the largest sources of hard currency (Torres, 1996).

After 1993, material flows and MFA derived indicators recovered and developed on an overall lower level compared to the 1970s and 1980s. Energy use (except electricity and natural gas) and material use (except nickel and citrus fruit) stabilized below the level of 1989.

In the 1993-2003 period two strategies were pursued: the development of the service sector (tourism, biotechnology, pharmaceutical industry) and the utilisation of natural resources (nickel, sugar cane) for social and economic development. After 1993 a growing service sector, lower material use and a continuous relative decoupling of material consumption (DMC), economic growth (GDP) and human development (HDI) respectively were observed. Increasing dematerialization of the economy in that time was mainly the result of accelerated economic growth along with stable material consumption. Stagnant material consumption in the 1990s needs to be interpreted as an expression of material shortage and eventually decreased the wellbeing of society during the economic crisis. Further studies need to be conducted on the biophysical side of services (tourism) in terms of energy intensity and material use.

As the only country in the world, Cuba achieved high human development and an ecological footprint below the globally available biocapacity. From a material flow perspective, the low ecological footprint appears to be the result of the economic crisis and energy shortage during the 1990s. There is no easy answer to the question whether the Cuban development model is sustainable or not, since one criteria of sustainable development is social acceptability.

An agricultural development model based on extractive activities, intensive in material, does not offer an expansion potential for the future. The traditional specialization in raw material export would increase social metabolism and encounter natural limits (due to limited land area for food and energy production and finite mineral deposits). In addition, the export of cash crops would increase the vulnerability to the fluctuations of the global economy. High environmental costs and diminishing returns due to low price elasticity and falling commodity terms of trade for raw materials on the global market need to be considered (Raffer, 2002).

Cuba could specialize in service sectors of comparative advantage linked with medicine, biotechnology and the pharmaceutical industry for the creation of new income sources. A selective and moderate opening of its economy should happen in line with environmental standards designed for the protection of its natural resources and ecosystems. Government regulation could help to support the allocation of natural resources and monitor the level of material consumption.

The Cuban example shows how closely the functioning of economy is linked to land, energy and material use, and vice versa how material use follows economic development. Cuba has learned to manage limited land and energy sources, developing emergency strategies and sustainability measures in order to survive under economically deficient conditions. The Cuban case study is a deconstruction of the predominant Western development model based on energy and material-intensive economic growth.

Sustainable energy and material use is the base of every powerful economy. Clean environment and resource availability are thresholds to social and economic development, since there is no substitute for biodiversity and the functioning of ecosystems. I hope that social, ecological and economic principles will guide Cuba on its path towards further sustainable development in the future.

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List of Abbreviations

Au	Gold
COMECON	Council for Mutual Economic Assistance
MFA	material flow analysis/material flow accounting
GDP	gross domestic product
DE	domestic extraction
DM	dry matter
DMC	domestic material consumption
DMI	domestic material input
EF	ecological footprint
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistical Database
FDI	Foreign Direct Investment
GM	green matter
HDI	Human Development Index
IEA	International Energy Agency
m.c.	moisture content
POP	population
PTB	physical trade balance
USD	US Dollar
UNDP	United Nations Development Program
UN	United Nations
USGS	U.S. Geological Survey
ONE	Oficina Nacional de Estadistica
PPP	Purchasing Power Parity
Co	Cobalt
Ni	Nickel
USA	United States of America
U.S.	United States
CO_2	Carbon Dioxide
MI	material intensity

Units

cap	capita
t, m.t.	ton (s), metric tonne (s)
MJ	mega joule
m^3	solid cubic meter
kg	kilogram(s)
km	kilometer
km^2	square kilometer
ha	hectar(s)
%	percent
yr	year
mos.	month(s)

9. Annex

9.1. Cuba Country Facts

Country Name: Republica de Cuba (Republic of Cuba)

Capital: La Habana (Havana)

Location: 21.30 N, 80.00 W

Island in the Antil Archipel located between the Caribbean Sea and the North Atlantic Ocean

Land Area: 110,860 km^2

Climate: Tropical, moderated by trade winds, dry season (November to April), rainy season (May-October)

Government type: Socialist

Independence: 20 May 1902 (from the US), 10 December 1898 (from Spain)

Constitution: 24 February 1976, amended July 1992 and June 2002

Currency: Peso Cubano (CUP), Peso Convertible (CUC)

Population: 11,423,952

Language: Spanish

Ethnic groups: Mulatto (51%), White (37%), Black (11%), Chinese (1%)

Religions: nominally 85% Roman Catholic; Protestants, Jehovah´s Witnesses, Jews and Santeria

International organization participation: ACP, FAO, G-77, IAEA, ICAO, ICC, ICRM, IFAD, IFRCS, IHO, ILO,IMO, Interpol, IOC; IOM (observer), IPU, ISO; ITU, LAES, LAIA, NAM, OAS (excluded from formal participation since 1962), OPANAL, OPCW; PCA, UN, UNCTAD, UNESCO, UNIDO,UPU,WCL, WCO, WFTU,WHO,WIPO, WMO, WTO

International Environmental Agreements:
Signed and ratified: Antarctic Treaty, Biodiversity, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Environmental Modification, Hazardous Wastes, Law of the Sea, Marine Dumping, Ozone Layer Protection, Ship Pollution, Wetlands
Signed but not ratified: Marine Life Conservation (source: CIA 2007)

9.2. Social Indicators

A country comparison was chosen using specific social indicators in order to provide reference values and to discuss Cuba's performance in selected social spheres (health, education, economy, human development, security, science, environment, transport and communication) in a global context. The United States of America was selected representative for any industrialized, high-income nation and could theoretically be replaced by any other country of this group.

Country data on Cuba and the United States comes from the World Bank (2007), CIA (2007), UNDP (2007), the U.S. Disaster Center (2007) and the U.S Bureau of Justice Statistics (2007)

The Republic of Cuba is a small island state located in the Antil Archipel, 150 km south of Key West, Florida. Its land area is 110,860 km^2, comprising mainly flat to rolling plains, with rugged hills and mountains in the southeast. Its climate is tropical with a dry season from November to April and a rainy season from May to October. Cuba has a total population of 11.4 million inhabitants, growing 0.25% per year and a relatively high population density of 103 inhabitants per square kilometer (CIA 2008). Cuba is one of the last Socialist countries in the world. Its average national income amounts to 6,000 USD PPP/cap, and lies far below the income level of fully industrialized countries. Nevertheless it ranks among the top countries in the world regarding social and ecological parameters.

As far as economic performance and standard of living are concerned, the USA clearly outmatches Cuba. The national per capita income in the United States is a multiple of the one in Cuba whilst the Cuban economy is growing faster than the American one. Likewise the USA has a lead in the R&D, transport and telecommunication sectors. Investment for R&D in the USA is four times as high. By comparison, in the U.S. there are nearly 50 times more Internet Users, 14 times more telephone extensions and 30 times more PCs than in Cuba.

In regard to health, education, environment and security, Cuba shows an overall better performance. Despite its lower economic performance, the Cuban state spends a higher share of GDP for education and health than the US government. In Cuba, investments devoted to the educational system are higher, the combined primary and secondary enrollment rate is somewhat higher and the illiteracy rate is below the American one. Overall security is higher in Cuba due to a relatively high mortality and high theft rate in the USA. Thanks to its ubiquitous health care, Cuba has more hospital beds available per citizen, more births in attendance of skilled health staff, less stillbirths, lower child mortality and a higher child immunization rate. Generally, Cuba shows sustainable energy consumption patterns and low per-capita emissions. In the USA, per capita energy consumption is 8 times higher, per capita CO_2 emissions are almost 9 times as much and the electricity use amounts to a level almost 11 times higher.

Tab. 30: Social Indicators

Indicator	Year	Cuba	United States
People:			
Population, total (mio. cap):	2008***	11.40	303.80
Life expectancy at birth (years):	2005**	77.70	77.90
Fertility Rate (births per women):	2005*	1.50	2.05
Death Rate, crude (per 1,000 cap):	2005*	7.20	8.25
Mortality, adult male (15-59 yrs. per 1,000 cap):	1999-2005*	121.00	144.00
Child Malnutrition (% under 5 years):	1999-2005*	4.00	2.00
Security:			
Prison Population (per 100.000 cap):	2005**	487.00	738.00
Thefts (per 100.000 cap):	1988	****62.00	*****5,027
Human Development:			
Human Development Index (HDI):	2005**	0.838	0.951
Life expectancy Index:		0.879	0.881
Education Index:		0.952	0.971
Income Index:		0.683	1.000

Economy:			
GDP (billion constant 1990 USD):	2005**	38.44	9 276.65
GDP per capita (PPP constant USD/cap):	2005**	6,000.00	41,890.00
GDP growth rate (annual %):	2005*	5.40	3.20
GDP composition by sector:			
Agriculture:	2007***	21.20	0.90
Industry:		26.10	20.60
Services:		68.40	78.50
Unemployment (% of total labour force):	2002*	3.30	5.80
Education:			
Public Expenditure Education (% of GDP):	1999-2005*	9.80	5.85
Literacy, total (% of ages 15+):	2005	*99.80	***99.00
Gross Enrollment (Primary & Secondary. % of age group):	2005*	98.00	97.00
Health:			
Public Expenditure Health (% of GDP):	1999-2005*	5.50	6.90
Hospital beds (per 1,000 people):	2003*	4.90	3.30
Births attended by skilled health staff (% of total):	2004*	100.00	99.00
Child immunization, measles (% of ages12-23 mos.):	1999-2005*	98.00	93.00
Child immunization, DPT (% of ages12-23 mos.):	1999-2005*	99.00	96.00
Infant Mortality Rate (per 1,000 live births):	2004*	6.30	6.70
Under-five mortality rate (per 1,000<5):	2004*	7.40	7.60
Life Style (Transport and Communication):			
Personal computers (per 1,000 cap):	2005*	26.68	762.15
Internet users (per 1,000 cap):	2004*	13.34	626.99
Fixed line and mobile subscribers (per 1,000 cap):	2005*	87.00	1,227.00
Paved roads (% of total network):	2000*	49.00	59.00
Science:			
Public Expenditure R&D (% of GDP):	2003*	0.65	2.67
Physicians (per 1,000 people):	2002*	5.91	2.30
High technology exports (% of manufactured exports):	2000*	21.00	35.00
Environment:			
Deforestation (average annual %):	1990-2005*	-2.10	-0.1
CO2 Emissions (t/cap):	2005*	2.25	19.90
Access to improved water source (% of total pop.):	2005*	91.00	100.00
Access to improved sanitation (% of urban pop.):	2005*	99.00	100.00
Energy use per capita (kg oil equivalent):	2005*	950.30	7,920.00
Electricity use per capita (kilowatt-hours):	2005*	1,177.00	13,351.00

Source: *World Bank (2007) World Development Indicators Database, The Little Data Book

**UNDP (2007) Human Development Report

***CIA (2007) The World Factbook

****U.S. Disaster Center (2007)

*****U.S Bureau of Justice Statistics (2007)

9.3. Domestic Extraction, Import and Export Data

Table A: Domestic extraction
units: 1,000 metric tons

1digit	2digit	3digit	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
A.1. Biomass			134,820.11	96,006.26	85,374.29	89,924.34	93,573.26	92,908.79	95,152.26	104,111.15	116,648.23	127,114.34	109,359.57	113,238.43	121,850.58	117,365.91	128,126.33	114,848.04	116,367.05
	A.1.1. Primary crops		84,455.60	56,335.32	48,558.69	52,175.43	55,215.48	54,635.42	55,812.65	62,757.88	72,272.28	79,859.49	66,685.52	69,638.05	75,993.58	72,646.65	80,549.03	70,755.16	71,832.27
		A.1.1.1. Cereals	462.72	443.33	408.97	423.63	532.55	541.35	546.18	551.87	553.56	521.20	573.93	556.99	615.85	613.74	650.86	620.42	666.62
		A.1.1.2. Roots, tubers	539.47	544.75	567.65	548.28	599.27	647.42	697.09	765.58	946.64	892.85	736.83	729.00	624.60	625.14	679.34	679.85	675.16
		A.1.1.3. Sugar crops	82,900.00	54,700.00	46,800.00	50,270.00	52,914.00	52,389.01	53,486.00	60,353.01	69,653.01	77,311.41	63,977.41	66,678.50	73,100.00	69,700.00	77,400.00	67,400.00	68,500.00
		A.1.1.4. Pulses	11.00	11.00	14.00	6.00	5.00	4.00	3.00	6.00	7.00	8.00	9.38	8.18	12.18	12.74	11.69	11.00	13.20
		A.1.1.5. Nuts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.1.1.6. Oil bearing crops	25.23	25.58	27.10	31.78	29.18	29.49	22.89	26.68	27.21	30.08	34.39	32.16	34.86	37.88	34.56	34.45	36.93
		A.1.1.7. Vegetables	139.77	206.92	177.73	282.03	500.86	425.55	393.87	331.47	317.40	327.11	444.38	627.55	523.67	453.31	509.25	595.69	553.34
		A.1.1.8. Fruits	306.01	332.85	478.00	527.51	522.99	494.53	542.96	628.41	681.37	679.70	853.47	896.23	973.96	1,115.64	1,156.98	1,306.02	1,282.96
		A.1.1.9. Fibres	18.60	18.80	18.40	19.88	36.80	40.36	40.54	33.57	28.69	32.65	27.29	31.70	33.13	37.78	37.74	37.43	31.84
		A.1.1.10. Other crops (Spices. Stimulant crops, Tobacco, Rubber)	52.80	52.10	66.84	66.32	74.84	63.70	80.13	61.30	57.41	56.49	28.43	77.75	75.34	50.43	68.62	70.32	72.22
	A.1.2. Crop residues (used)		36,364.36	24,222.30	20,808.28	22,302.83	23,565.19	23,373.01	23,876.67	26,872.00	30,965.81	34,204.23	28,438.38	29,585.44	32,351.59	30,888.74	34,263.65	29,932.42	30,436.68
		A.1.2.1. Straw	431.00	414.14	383.68	396.13	494.85	502.42	506.82	512.11	513.61	484.78	531.76	516.66	569.11	567.23	600.30	573.18	614.34
		A.1.2.2. Other crop residues (sugar and fodder beet leaves, other)	35,933.36	23,808.16	20,424.60	21,906.70	23,070.34	22,870.60	23,369.85	26,359.90	30,452.21	33,719.45	27,906.62	29,068.78	31,782.47	30,321.51	33,663.35	29,359.24	29,822.34
	A.1.3. Fodder crops incl. grassland harvest		1,576.71	1,452.87	1,419.37	1,347.79	1,633.69	1,384.65	1,482.28	2,094.05	1,438.84	2,136.23	2,086.98	1,668.84	2,058.20	1,831.74	2,408.64	1,873.95	1,842.16
		A.1.3.1. Fodder crops	1,576.71	1,452.87	1,419.37	1,347.79	1,633.69	1,384.65	1,482.28	2,094.05	1,438.84	2,136.23	2,086.98	1,668.84	2,058.20	1,831.74	2,408.64	1,873.95	1,842.16
		A.1.3.2. Biomass harvested from grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.1.4. Grazed biomass		10,871.98	12,205.50	12,815.11	12,207.52	11,342.34	11,726.30	12,150.90	10,779.30	10,157.69	8,549.05	9,782.79	9,984.91	8,999.37	9,622.16	8,512.72	9,890.59	9,732.43
	A.1.5. Wood		1,447.16	1,663.36	1,633.33	1,740.49	1,652.13	1,646.17	1,637.37	1,426.26	1,600.64	2,212.14	2,179.49	2,196.41	2,253.18	2,178.19	2,192.48	2,176.11	2,279.00
		A.1.5.1. Timber (Industrial roundwood)	423.17	448.36	447.17	463.55	463.55	464.30	515.20	470.32	454.77	487.78	495.47	493.91	522.03	517.02	527.05	530.31	633.27
		A.1.5.2. Wood fuel and other extraction	1,023.99	1,214.99	1,186.17	1,276.94	1,188.58	1,181.87	1,122.16	955.94	1,145.87	1,724.36	1,684.03	1,702.50	1,731.15	1,661.17	1,665.43	1,645.80	1,645.73
	A.1.6. Fish capture, crustaceans, molluscs and aquatic invertebrates		104.30	126.91	139.51	150.29	164.43	143.25	192.39	181.66	212.98	153.20	186.41	164.79	194.67	198.43	199.81	219.81	244.51
	A.1.7. Hunting and gathering		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.2. Metal ores (gross ores)			3,967.18	3,920.84	4,134.39	3,986.73	3,907.93	4,266.76	4,215.90	4,168.21	3,988.54	3,752.86	4,432.65	4,606.70	4,320.10	4,544.20	3,958.08	4,138.40	4,154.45
	A.2.1. Iron ores		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	1.00	2.00	38.00	93.30	202.00	20.00
	A.2.2. Non-ferrous metal ores		3,967.18	3,920.84	4,134.39	3,986.73	3,907.93	4,266.76	4,215.90	4,168.21	3,988.54	3,752.86	4,428.65	4,605.70	4,318.10	4,506.20	3,864.78	3,936.40	4,134.45
		A.2.2.1. Copper ores	0.00	0.00	146.45	168.90	230.62	222.61	227.42	207.06	226.13	229.98	269.42	236.64	214.35	215.47	216.52	246.58	261.08
		A.2.2.2. Nickel ores	3,776.47	3,743.61	3,777.90	3,614.63	3,479.07	3,833.15	3,801.73	3,773.90	3,572.32	3,319.39	3,923.52	4,134.35	3,861.50	4,031.35	3,412.12	3,448.06	3,604.66
		A.2.2.3. Lead ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.4. Zinc ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.5. Tin ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.6. Gold, silver, platinum and other precious metal ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.7. Bauxite and other aluminium ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.8. Uranium and thorium ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.9. Other metal ores	190.71	177.23	210.03	203.20	198.23	211.00	186.76	187.25	190.09	203.49	235.71	234.72	242.25	259.38	236.15	241.77	268.70
A.3. Non metalic minerals			13,473.95	18,735.05	23,015.36	36,505.63	30,040.78	30,753.70	33,982.60	35,495.37	36,988.30	37,432.12	37,277.20	37,113.34	36,441.84	36,893.86	45,985.20	46,074.79	47,374.44
	A.3.1. Ornamental or building stone		0.00	0.00	0.00	0.00	20.50	20.50	12.82	17.94	17.94	25.63	23.07	20.50	25.63	35.88	35.88	48.70	58.95
	A.3.2. Limestone, gypsum, chalk, and dolomite		3,072.79	4,505.65	6,104.16	7,276.13	7,597.18	9,850.89	10,175.33	10,035.26	11,094.99	10,701.53	9,544.97	11,178.10	11,039.60	12,067.11	12,844.90	13,253.75	13,108.91
	A.3.3. Slate		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.3.4. Gravel and sand		10,279.46	14,092.40	16,738.20	29,033.50	22,220.10	20,626.20	23,577.46	25,213.17	25,656.36	26,520.96	27,409.16	25,642.74	25,042.61	24,469.87	32,775.31	32,397.74	33,805.68
	A.3.5. Clays and kaolin		8.70	0.00	0.00	0.00	0.00	24.10	0.00	17.00	34.00	32.00	84.00	78.00	88.00	88.00	100.00	98.00	86.00
	A.3.6. Chemical and fertilizer minerals		24.00	34.00	71.00	72.00	65.00	75.00	66.00	82.00	54.00	29.00	53.00	33.00	48.00	13.00	0.00	0.00	0.00
	A.3.7. Salt		89.00	103.00	102.00	124.00	138.00	157.00	151.00	130.00	131.00	123.00	131.00	161.00	198.00	180.00	184.00	221.00	266.00
	A.3.8. Other mining and quarrying products n.e.c.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.00	0.00	0.00	40.00	45.10	55.60	48.90
	A.3.9. Excavated soil, only if used (e.g. for construction work)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.4. Fossil energy carriers			138.34	138.34	139.36	168.30	207.24	272.22	285.40	306.22	338.54	343.06	327.06	303.04	625.86	854.12	772.52	881.32	951.56
	A.4.1. Brown coal incl. oil shale and tar sands		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.4.2. Hard coal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.4.3. Petroleum		0.00	137.00	134.00	157.00	192.00	259.00	269.00	293.00	330.00	329.00	313.00	296.00	618.00	848.00	770.00	876.00	947.00
	A.4.4. Natural gas		0.00	1.34	5.36	11.30	15.24	13.22	16.40	13.22	8.54	14.06	14.06	7.04	7.86	6.12	2.52	5.32	4.56
	A.4.5. Peat		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table A: Domestic extraction
units: 1,000 metric tons

1digit	2digit	3digit	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
A.1. Biomass			119,007.01	123,392.47	133,372.51	134,237.23	129,826.24	111,201.36	79,997.53	80,161.54	66,962.78	78,168.24	74,494.99	66,226.59	67,604.87	72,257.19	66,710.25	70,809.30	57,143.53
	A.1.1. Primary crops		74,058.68	77,378.15	84,358.05	85,114.40	82,911.92	70,032.08	46,537.64	45,937.90	36,817.82	45,268.18	42,882.50	36,865.12	39,414.74	43,514.35	39,941.30	42,693.76	32,641.28
		A.1.1.1. Cereals	562.14	584.96	617.48	539.82	484.07	442.43	254.70	487.20	500.90	717.80	817.70	619.20	796.89	826.20	900.12	1,001.18	1,075.96
		A.1.1.2. Roots, tubers	633.05	653.18	690.20	617.68	690.45	850.54	708.99	598.76	759.14	903.50	827.28	817.57	1,059.25	1,230.84	1,380.54	1,437.03	1,777.32
		A.1.1.3. Sugar crops	70,801.81	73,744.61	81,002.90	81,800.00	79,700.00	66,300.00	43,700.00	43,200.00	33,600.00	41,300.00	38,900.00	32,800.00	34,000.00	36,400.00	32,100.00	34,700.00	22,901.60
		A.1.1.4. Pulses	12.54	14.84	14.11	14.00	11.85	20.12	18.31	22.32	24.54	29.10	33.40	42.22	76.82	106.30	99.11	107.30	127.00
		A.1.1.5. Nuts	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.1.1.6. Oil bearing crops	39.27	40.47	39.40	40.00	39.00	20.91	26.28	24.61	26.70	32.10	38.44	51.90	55.88	90.15	98.69	118.59	120.60
		A.1.1.7. Vegetables	543.05	677.17	574.46	474.22	477.50	649.11	504.50	411.70	547.96	658.22	627.52	871.01	1,467.21	2,397.37	2,703.18	3,370.75	3,895.60
		A.1.1.8. Fruits	1,368.86	1,570.03	1,311.52	1,535.53	1,426.34	1,674.41	1,257.87	1,129.70	1,286.89	1,549.90	1,558.34	1,582.45	1,876.72	2,384.35	2,582.81	1,880.91	2,664.71
		A.1.1.9. Fibres	30.81	22.43	34.90	28.70	28.20	28.20	28.20	28.20	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50	27.50
		A.1.1.10. Other crops (Spices. Stimulant crops, Tobacco, Rubber)	67.16	70.47	73.09	64.46	54.52	46.36	38.79	35.42	44.19	50.07	52.32	53.27	54.48	51.64	49.36	50.50	50.99
	A.1.2. Crop residues (used)		31,315.62	32,617.45	35,780.55	36,016.98	35,100.50	29,396.59	19,420.23	19,364.20	15,330.46	18,918.72	17,942.78	15,136.49	15,947.95	17,114.90	15,417.50	16,640.66	11,830.50
		A.1.2.1. Straw	521.25	541.58	567.38	495.01	443.28	408.23	241.60	455.22	468.53	670.30	771.74	589.38	760.50	794.14	865.46	957.64	1,035.08
		A.1.2.2. Other crop residues (sugar and fodder beet leaves, other)	30,794.37	32,075.87	35,213.17	35,521.97	34,657.22	28,988.36	19,178.63	18,908.97	14,861.92	18,248.42	17,171.04	14,547.11	15,187.45	16,320.76	14,552.05	15,683.02	10,795.42
	A.1.3. Fodder crops incl. grassland harvest		2,518.90	2,856.88	3,266.25	3,098.60	2,796.80	2,145.34	1,613.46	1,773.64	1,517.08	1,277.07	1,505.25	1,234.49	1,582.09	1,678.95	1,701.57	1,745.97	0.00
		A.1.3.1. Fodder crops	2,518.90	2,856.88	3,266.25	3,098.60	2,796.80	2,145.34	1,613.46	1,773.64	1,517.08	1,277.07	1,505.25	1,234.49	1,582.09	1,678.95	1,701.57	1,745.97	0.00
		A.1.3.2. Biomass harvested from grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.1.4. Grazed biomass		8,703.52	8,078.25	7,635.16	7,394.69	6,353.56	6,975.77	9,695.68	10,348.38	10,549.50	9,963.28	9,417.30	10,276.28	9,224.94	8,268.58	8,053.84	7,488.32	10,493.81
	A.1.5. Wood		2,195.57	2,230.70	2,140.67	2,424.46	2,492.44	2,540.47	2,633.00	2,644.36	2,646.01	2,619.05	2,618.20	2,600.42	1,312.61	1,571.56	1,485.71	2,130.27	2,067.61
		A.1.5.1. Timber (Industrial roundwood)	615.14	598.77	645.33	627.37	625.13	598.20	596.71	596.71	596.71	596.71	596.71	596.71	460.64	790.24	761.51	680.10	701.76
		A.1.5.2. Wood fuel and other extraction	1,580.43	1,631.93	1,495.35	1,797.09	1,867.31	1,942.27	2,036.29	2,047.65	2,049.30	2,022.34	2,021.49	2,003.71	851.97	781.32	724.20	1,450.17	1,365.85
	A.1.6. Fish capture, crustaceans, molluscs and aquatic invertebrates		214.72	231.03	191.82	188.10	171.02	111.11	97.53	93.06	101.92	121.94	128.96	113.79	122.54	108.85	110.33	110.33	110.33
	A.1.7. Hunting and gathering		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.2. Metal ores (gross ores)			4,504.88	5,324.48	5,493.95	4,575.61	4,200.24	3,770.57	3,343.47	3,194.42	4,910.73	6,114.21	7,049.33	8,070.34	8,002.68	8,443.65	8,169.16	8,026.62	8,298.55
	A.2.1. Iron ores		169.00	294.00	171.00	255.00	180.00	134.00	91.00	131.00	207.00	231.00	342.00	283.30	302.60	327.30	269.60	264.10	268.00
	A.2.2. Non-ferrous metal ores		4,335.88	5,030.48	5,322.95	4,320.61	4,020.24	3,636.57	3,252.47	3,063.42	4,703.73	5,883.21	6,707.33	7,787.04	7,700.08	8,116.35	7,899.56	7,762.52	8,030.55
		A.2.2.1. Copper ores	277.44	236.56	221.16	160.32	160.32	120.24	120.24	232.47	160.32	189.34	177.00	108.30	87.38	107.90	80.16	80.16	80.16
		A.2.2.2. Nickel ores	3,782.63	4,511.02	4,784.59	3,943.34	3,635.27	3,305.63	2,975.17	2,648.10	4,194.42	5,266.93	6,062.99	6,683.14	6,614.03	6,989.57	7,453.84	7,326.19	7,600.99
		A.2.2.3. Lead ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.4. Zinc ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.5. Tin ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.6. Gold, silver, platinum and other precious metal ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	122.67	166.67	166.67	666.67	666.67	666.67	0.00	0.00	0.00
		A.2.2.7. Bauxite and other aluminium ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.8. Uranium and thorium ores	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		A.2.2.9. Other metal ores	275.81	282.91	317.20	216.95	224.65	210.70	157.06	152.86	226.33	260.28	300.68	328.94	332.01	352.21	365.57	356.16	349.40
A.3. Non metalic minerals			50,120.01	44,381.67	45,647.13	41,112.94	39,881.79	37,762.13	18,968.28	20,434.98	24,317.32	23,653.68	25,866.47	26,019.20	26,812.71	25,329.64	22,193.30	22,277.28	22,520.37
	A.3.1. Ornamental or building stone		61.51	69.20	64.08	0.00	0.00	0.00	0.00	0.00	0.00	5.43	5.45	6.89	6.92	10.40	0.00	0.00	0.00
	A.3.2. Limestone, gypsum, chalk, and dolomite		13,757.80	15,283.16	15,149.23	13,485.44	12,967.79	12,093.13	4,473.28	4,619.06	6,161.28	6,084.66	7,172.56	7,225.57	7,520.43	6,891.37	5,613.39	5,624.99	5,702.02
	A.3.3. Slate		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.3.4. Gravel and sand		35,900.90	28,704.90	30,115.83	27,422.50	26,710.00	25,479.00	14,305.00	15,629.72	17,954.04	17,371.19	18,493.66	18,621.74	19,106.06	18,229.47	16,397.01	16,464.09	16,627.55
	A.3.5. Clays and kaolin		114.00	86.00	112.00	0.00	0.00	0.00	0.00	4.20	12.70	15.50	11.50	11.00	10.40	9.70	8.10	2.40	2.90
	A.3.6. Chemical and fertilizer minerals		0.00	0.00	0.00	5.00	4.00	5.00	5.00	4.00	0.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	A.3.7. Salt		231.00	200.00	206.00	200.00	200.00	185.00	185.00	175.00	180.00	159.80	163.60	134.60	159.10	177.00	163.40	176.10	175.70
	A.3.8. Other mining and quarrying products n.e.c.		54.80	38.40	0.00	0.00	0.00	0.00	0.00	3.00	9.30	12.10	14.70	14.40	4.80	6.70	6.40	4.70	7.20
	A.3.9. Excavated soil, only if used (e.g. for construction work)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.4. Fossil energy carriers			921.24	740.72	751.84	696.62	549.50	897.88	1,125.48	1,314.04	1,484.14	1,490.66	1,490.28	1,772.40	2,485.60	3,131.32	3,337.90	4,072.38	4,072.38
	A.4.1. Brown coal incl. oil shale and tar sands		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.4.2. Hard coal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	A.4.3. Petroleum		903.00	724.00	726.00	671.00	527.00	882.00	1,108.00	1,299.00	1,471.00	1,476.00	1,462.00	1,678.00	2,136.00	2,695.00	2,886.00	3,628.00	3,628.00
	A.4.4. Natural gas		18.24	16.72	25.84	25.62	22.50	15.88	17.48	15.04	13.14	14.66	28.28	94.40	349.60	436.32	451.90	444.38	444.38
	A.4.5. Peat		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B: Imports
units: 1,000 metric tons

1digit	2digit	3digit	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
B.1. Biomass and biomass products			3,031.95	3,302.48	3,121.86	3,095.18	3,501.91	3,693.03	3,689.95	3,658.69	3,860.10	3,878.47	4,839.14	4,448.75	4,152.16	4,367.56	4,611.61	4,744.32	4,678.47
	B .1.1. Primary crops		1,407.30	1,605.16	1,603.67	1,609.98	1,898.51	1,809.54	2,027.93	2,140.40	2,199.63	2,154.04	2,744.11	2,539.77	2,381.56	2,665.63	2,771.93	2,833.75	2,780.67
		B.1.1.1. Cereals, primary and processed	1,065.36	1,263.44	1,297.51	1,261.98	1,516.86	1,456.10	1,632.44	1,662.82	1,767.81	1,736.62	2,236.84	2,060.68	1,879.99	2,091.43	2,109.77	2,201.03	2,128.32
		B.1.1.2. Roots and tubers, primary and processed	31.63	30.11	16.19	27.11	32.64	27.59	24.76	55.55	51.40	51.80	39.92	40.70	40.50	26.01	30.04	29.95	30.05
		B.1.1.3. Sugar crops, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.1.1.4. Pulses, primary and processed	86.71	82.62	89.71	95.68	110.43	76.50	106.43	116.02	106.01	87.11	104.24	102.67	119.18	107.27	124.72	127.82	93.61
		B.1.1.5. Nuts, primary and processed	0.57	0.55	0.52	0.50	0.45	0.40	0.30	0.20	0.12	0.12	0.08	0.08	0.07	0.02	0.07	0.07	0.09
		B.1.1.6. Oil bearing crops, primary and processed	137.84	152.18	124.22	147.99	164.25	169.50	201.35	228.94	194.94	204.29	250.34	232.40	247.43	341.11	410.86	381.94	435.31
		B.1.1.7. Vegetables, primary and processed	11.85	19.16	12.28	13.32	12.25	11.35	6.57	14.38	16.14	11.15	24.80	17.51	18.98	24.24	16.19	14.63	17.56
		B.1.1.8. Fruits, primary and processed	23.22	24.96	25.98	20.77	22.08	12.03	9.69	7.49	13.82	18.00	19.49	20.45	16.42	20.62	20.73	19.01	14.87
		B.1.1.9. Fibres, primary and processed	21.58	20.19	20.59	20.52	19.29	25.49	20.64	41.81	29.82	32.79	45.55	44.71	46.25	46.83	49.46	52.27	52.20
		B.1.1.10. Other crops (Spices. Stimulant crops, Tobacco, Rubber..)	28.55	11.95	16.68	22.10	20.26	30.59	25.76	13.20	19.57	12.15	22.85	20.57	12.74	8.11	10.10	7.03	8.67
	B.1.2. Crop residues		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.1.2.1. Straw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.1.2.2. Other crop residues (sugar and fodder beet leaves, other)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.3. Fodder crops incl. grassland harvest		41.12	55.36	62.47	69.59	83.82	98.05	123.87	149.69	175.50	188.41	201.32	184.99	214.44	168.66	227.56	146.44	205.04
		B.1.3.1. Fodder crops	41.12	55.36	62.47	69.59	83.82	98.05	123.87	149.69	175.50	188.41	201.32	184.99	214.44	168.66	227.56	146.44	205.04
		B.1.3.2. Biomass harvested from grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.4.n..a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.5. Wood primary and processed		337.68	343.33	299.93	316.93	448.81	448.51	357.67	381.47	458.85	397.63	539.59	487.01	552.96	564.66	691.61	744.87	678.39
		B.1.5.1. Timber, primary and processed	307.68	304.33	268.93	285.93	417.81	417.51	326.67	350.47	426.65	359.23	491.69	455.11	511.46	518.96	650.31	699.57	637.79
		B.1.5.2. Wood fuel and other extraction, primary and processed	30.00	39.00	31.00	31.00	31.00	31.00	31.00	31.00	32.20	38.40	47.90	31.90	41.50	45.70	41.30	45.30	40.60
	B.1.6. Fish capture, crustaceans, molluscs and aquatic invertebrates p. n. p.		258.23	380.70	427.49	200.84	185.05	399.12	240.64	262.88	356.46	326.61	522.24	361.32	146.29	181.76	111.75	139.43	183.83
	B.1.7. n.a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.8. Live animals other than in B 1.6., meat and meat products		987.61	917.94	728.30	897.84	885.72	937.81	939.84	724.25	669.66	811.78	831.89	875.67	856.91	786.86	808.76	879.83	830.55
		B.1.8.1. Live animals other than in B 1.6.	7.88	7.89	3.06	3.33	3.56	4.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.1.8.2. Meat and meat preparations	97.49	80.11	86.76	113.75	152.67	205.15	100.05	103.12	137.52	156.41	189.85	194.04	242.36	209.30	221.30	225.34	202.92
		B.1.8.3. Dairy products, birds eggs, and honey	882.12	829.95	638.49	780.76	729.49	728.66	835.79	621.13	532.14	655.38	642.04	681.64	614.56	577.56	587.46	654.48	627.62
		B.1.8.4. Other products from animals (animal fibres, skins, furs, leather etc.)	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.9. Products mainly from biomass		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.2. Metal ores and concentrates, processed metals			175.50	237.92	269.12	300.33	362.75	425.17	458.86	492.55	526.25	543.09	559.94	646.53	724.15	733.12	888.36	948.88	932.27
	B.2.1. Iron ores and concentrates, iron and steel		175.50	237.92	269.12	300.33	362.75	425.17	458.86	492.55	526.25	543.09	559.94	646.53	724.15	733.12	888.36	948.88	932.27
	B.2.2. Non-ferrous metal ores and concentrates, processed metals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.2.2.1. Copper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.2. Nickel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.3. Lead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.4. Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.5. Tin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.6. Gold, silver, platinum and other precious metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.7. Aluminium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.8. Uranium and thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.9. Other metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.2.3. Products mainly from metals		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B.3. Non-metalic minerals, primary and processed			399.67	251.90	198.00	287.40	281.80	351.50	315.20	358.60	412.60	323.80	411.20	459.49	453.99	470.95	478.08	506.42	515.27
	B.3.1. Ornamental or building stone		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.2. Limestone, gypsum, chalk, and dolomite		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.3. Slate		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.4. Gravel and sand		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.5. Clays and kaolin		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.6. Chemical and fertilizer minerals		399.67	251.90	198.00	287.40	281.80	351.50	315.20	358.60	412.60	323.80	411.20	459.49	453.99	470.95	478.08	506.42	515.27
	B.3.7. Salt		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.8. Other mining and quarrying products n.e.c.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.3.9. Excavated soil, only if used (e.g. for construction work)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.3.10. Products mainly from non-metalic minerals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.4. Fossil energy carriers, primary and processed			7,603.00	7,603.00	7,529.00	8,934.00	9,496.00	9,572.00	10,150.00	10,416.00	10,965.00	10,840.00	11,527.00	12,111.00	13,323.00	13,507.00	12,621.00	13,906.00	12,957.00
	B.4.1. Brown coal incl. oil shale and tar sands		75.00	75.00	88.00	59.00	42.00	41.00	45.00	47.00	49.00	46.00	53.00	59.00	60.00	56.00	55.00	64.00	62.00
	B.4.2. Hard coal		52.00	52.00	52.00	45.00	47.00	57.00	48.00	89.00	91.00	76.00	90.00	87.00	124.00	90.00	92.00	126.00	119.00
	B.4.3. Petroleum		5,438.00	5,438.00	5,429.00	5,993.00	6,716.00	6,627.00	6,611.00	7,089.00	7,269.00	7,009.00	6,887.00	7,265.00	7,141.00	7,843.00	7,235.00	8,127.00	7,440.00
	B.4.4. Natural gas		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.4.5. Peat		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.4.6. Products mainly from fossil energy carriers		2,038.00	2,038.00	1,960.00	2,837.00	2,691.00	2,847.00	3,446.00	3,191.00	3,556.00	3,709.00	4,497.00	4,700.00	5,998.00	5,518.00	5,239.00	5,589.00	5,336.00
B.5. Other products			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.6. Waste imported for final treatment and disposal			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B: Imports
units: 1,000 metric tons

1digit	2digit	3digit	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
B.1. Biomass and biomass products			4,794.53	4,839.29	4,981.36	4,646.43	4,005.88	2,495.95	2,565.65	2,749.62	2,833.47	2,638.25	2,887.87	3,004.96	3,122.50	3,079.96	3,243.20	3,483.34	2,913.30
	B .1.1. Primary crops		2,940.69	2,983.97	3,114.52	2,972.68	2,375.69	1,846.58	1,878.08	1,902.71	1,972.05	1,816.67	2,008.82	1,994.16	2,141.35	2,038.24	2,205.08	2,262.01	2,613.90
		B.1.1.1. Cereals, primary and processed	2,278.95	2,328.19	2,425.24	2,248.40	1,847.50	1,299.49	1,368.44	1,327.27	1,429.13	1,333.37	1,423.27	1,466.64	1,544.28	1,562.82	1,623.04	1,642.46	1,780.91
		B.1.1.2. Roots and tubers, primary and processed	19.98	20.13	9.92	30.00	20.00	31.00	53.00	40.00	25.00	40.18	43.19	42.40	36.59	40.19	31.97	35.68	21.18
		B.1.1.3. Sugar crops, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	2.23	47.32	85.41	202.14
		B.1.1.4. Pulses, primary and processed	134.89	109.74	127.33	100.00	111.72	161.87	117.04	168.41	138.88	124.12	181.44	155.15	219.75	119.76	169.81	114.26	174.79
		B.1.1.5. Nuts, primary and processed	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.08	0.07	0.10	0.08	0.09
		B.1.1.6. Oil bearing crops, primary and processed	404.84	449.16	479.81	530.68	335.78	291.94	311.62	338.23	345.63	290.18	329.82	296.45	299.13	268.16	279.24	307.03	396.97
		B.1.1.7. Vegetables, primary and processed	10.71	8.89	4.50	5.70	5.53	8.42	5.36	4.44	4.60	5.19	5.36	5.66	8.69	8.76	26.57	52.21	10.57
		B.1.1.8. Fruits, primary and processed	24.17	14.63	12.52	11.85	8.84	8.50	8.50	9.15	9.40	9.15	9.25	8.95	9.10	7.90	8.73	7.98	8.39
		B.1.1.9. Fibres, primary and processed	59.63	47.58	47.10	36.82	36.72	34.65	6.92	6.82	8.24	7.22	6.72	8.42	6.92	13.47	5.77	5.77	4.51
		B.1.1.10. Other crops (Spices. Stimulant crops, Tobacco, Rubber..)	7.50	5.63	8.09	9.22	9.59	10.70	7.20	8.39	11.18	7.26	9.78	10.50	15.37	14.86	12.51	11.12	14.34
	B.1.2. Crop residues		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.1.2.1. Straw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.1.2.2. Other crop residues (sugar and fodder beet leaves, other)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.3. Fodder crops incl. grassland harvest		235.44	289.83	365.60	293.95	148.49	9.18	7.29	169.33	186.43	222.82	200.70	178.59	134.36	90.13	68.02	45.90	28.78
		B.1.3.1. Fodder crops	235.44	289.83	365.60	293.95	148.49	9.18	7.29	169.33	186.43	222.82	200.70	178.59	134.36	90.13	68.02	45.90	28.78
		B.1.3.2. Biomass harvested from grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.4.n..a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.5. Wood primary and processed		648.15	554.89	542.80	538.73	538.73	8.09	14.72	16.65	34.07	29.68	42.12	42.12	42.12	83.78	77.98	77.98	77.98
		B.1.5.1. Timber, primary and processed	597.45	511.79	499.70	495.83	495.83	7.18	14.17	15.88	29.87	27.48	40.72	40.72	40.72	81.38	75.58	75.58	75.58
		B.1.5.2. Wood fuel and other extraction, primary and processed	50.70	43.10	43.10	42.90	42.90	0.91	0.55	0.77	4.20	2.20	1.40	1.40	1.40	2.40	2.40	2.40	2.40
	B.1.6. Fish capture, crustaceans, molluscs and aquatic invertebrates p. n. p.		183.01	195.91	58.23	52.88	19.47	36.27	56.46	50.71	59.58	39.91	31.61	42.25	38.74	58.88	51.94	51.94	0.00
	B.1.7. n.a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.1.8. Live animals other than in B 1.6., meat and meat products		787.24	814.69	900.20	788.19	923.50	595.84	609.11	610.23	581.34	529.17	604.61	747.85	765.93	808.92	840.17	1,045.50	192.64
		B.1.8.1. Live animals other than in B 1.6.	0.00	0.04	0.47	3.46	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.44
		B.1.8.2. Meat and meat preparations	186.72	223.60	284.50	267.50	261.46	122.91	112.66	83.63	100.91	112.61	173.55	166.98	274.04	306.40	387.43	503.77	129.02
		B.1.8.3. Dairy products, birds eggs, and honey	600.52	591.05	615.23	517.23	661.84	472.93	496.44	526.60	480.43	416.57	431.07	580.87	491.88	502.50	452.72	541.69	63.15
		B.1.8.4. Other products from animals (animal fibres, skins, furs, leather etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.03	0.02
	B.1.9. Products mainly from biomass		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.2. Metal ores and concentrates, processed metals			869.66	870.58	932.16	1,058.47	459.65	132.41	101.43	82.63	169.52	227.51	217.47	207.43	187.35	167.26	157.22	147.18	176.62
	B.2.1. Iron ores and concentrates, iron and steel		869.66	870.58	932.16	1,058.47	459.65	132.41	101.43	82.63	169.52	227.51	217.47	207.43	187.35	167.26	157.22	147.18	176.62
	B.2.2. Non-ferrous metal ores and concentrates, processed metals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		B.2.2.1. Copper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.2. Nickel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.3. Lead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.4. Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.5. Tin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.6. Gold, silver, platinum and other precious metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.7. Aluminium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.8. Uranium and thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		B.2.2.9. Other metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.2.3. Products mainly from metals		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B.3. Non-metalic minerals, primary and processed			472.59	426.83	537.88	436.30	208.40	147.30	96.50	109.10	217.00	158.00	177.40	119.30	100.50	80.40	155.90	91.90	91.90
	B.3.1. Ornamental or building stone		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.2. Limestone, gypsum, chalk, and dolomite		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.3. Slate		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.4. Gravel and sand		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.5. Clays and kaolin		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.6. Chemical and fertilizer minerals		472.59	426.83	537.88	436.30	208.40	147.30	96.50	109.10	217.00	158.00	177.40	119.30	100.50	80.40	155.90	91.90	91.90
	B.3.7. Salt		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	B.3.8. Other mining and quarrying products n.e.c.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.3.9. Excavated soil, only if used (e.g. for construction work)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.3.10. Products mainly from non-metalic minerals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.4. Fossil energy carriers, primary and processed			13,757.00	14,013.00	13,947.00	10,396.00	8,319.00	7,025.00	6,449.00	6,733.00	7,184.00	7,805.00	8,172.00	8,028.00	7,694.00	7,888.00	7,611.00	8,133.00	8,093.00
	B.4.1. Brown coal incl. oil shale and tar sands		84.00	66.00	67.00	64.00	9.00	20.00	11.00	21.00	21.00	16.00	19.00	22.00	23.00	19.00	13.00	14.00	0.00
	B.4.2. Hard coal		85.00	95.00	214.00	153.00	106.00	47.00	70.00	87.00	77.00	1.00	16.00	19.00	23.00	22.00	13.00	26.00	0.00
	B.4.3. Petroleum		7,973.00	8,585.00	8,585.00	6,308.00	4,420.00	1,411.00	1,630.00	1,386.00	1,199.00	1,636.00	1,094.00	899.00	801.00	1,648.00	1,715.00	1,479.00	1,479.00
	B.4.4. Natural gas		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.4.5. Peat		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	B.4.6. Products mainly from fossil energy carriers		5,615.00	5,267.00	5,081.00	3,871.00	3,784.00	5,547.00	4,738.00	5,239.00	5,887.00	6,152.00	7,043.00	7,088.00	6,847.00	6,199.00	5,870.00	6,614.00	6,614.00
B.5. Other products			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B.6. Waste imported for final treatment and disposal			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table D: Exports
units: 1,000 metric tons

1digit	2digit	3digit	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
D.1. Biomass and biomass products			7,886.40	6,476.09	4,849.52	5,368.96	6,170.46	6,268.44	6,344.94	6,913.59	7,934.10	8,152.13	7,034.36	7,509.59	8,339.13	7,462.24	7,620.46	7,775.07	7,305.15
	D.1.1. Primary crops		7,863.50	6,455.40	4,828.66	5,343.34	6,137.00	6,242.39	6,320.19	6,882.49	7,881.98	8,097.99	6,961.87	7,459.69	8,287.02	7,389.84	7,547.85	7,688.74	7,210.18
		D.1.1.1. Cereals, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.1.2. Roots and tubers, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.74	22.18	11.21	18.77	15.82	10.06	19.37	28.24	32.24
		D.1.1.3. Sugar crops, primary and processed	7,805.94	6,407.21	4,764.41	5,257.22	6,040.47	6,140.14	6,219.56	6,751.97	7,671.33	7,866.06	6,711.44	7,136.85	7,885.13	6,928.34	7,092.76	7,135.87	6,648.97
		D.1.1.4. Pulses, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.04	0.09	0.13	0.00	0.05
		D.1.1.5. Nuts, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.1.6. Oil bearing crops, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.1.7. Vegetables, primary and processed	1.20	0.37	0.02	1.17	1.18	1.80	1.73	0.64	5.07	6.75	5.95	3.01	5.01	2.20	3.52	7.77	5.25
		D.1.1.8. Fruits, primary and processed	32.48	27.71	40.87	55.36	63.01	63.46	66.86	89.94	151.49	168.40	205.04	267.61	329.47	395.78	387.45	468.92	484.34
		D.1.1.9. Fibres, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	1.14	0.00	0.00	0.00	0.00
		D.1.1.10. Other crops (Spices. Stimulant crops, Tobacco, Rubber...)	23.88	20.11	23.35	29.59	32.35	36.99	32.05	39.94	39.36	34.61	28.23	32.08	50.41	53.37	44.62	47.95	39.34
	D.1.2. Crop residues		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.2.1. n.a.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.2.2. Other crop residues (sugar and fodder beet leaves, other)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.3. Fodder crops incl. grassland harvest		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.3.1. Fodder crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.3.2. Biomass harvested from grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.4. n.a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.5. Wood primary and processed		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.60	10.60	17.60	28.80	37.96	39.99	49.04
		D.1.5.1. Timber, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.5.2. Wood fuel and other extraction, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.60	10.60	17.60	28.80	37.96	39.99	49.04
	D.1.6. Fish capture, crustaceans, molluscs and aquatic invertebrates p.n.p		22.90	20.69	20.86	25.61	33.45	26.04	24.75	31.09	52.13	54.15	61.89	39.30	34.51	43.60	34.66	46.34	45.93
	D.1.7. n.a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.8. Live animals other than in 1.6., meat and meat products		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.1. Live animals other than in 1.6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.2. Meat and meat preparations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.3. Dairy products, birds eggs, and honey	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.4. Other products from animals (animal fibres, skins, furs, leather etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.9. Products mainly from biomass		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.2. Metal ores and concentrates, processed metals			36.74	34.58	33.76	40.85	37.18	34.77	39.46	49.82	44.72	44.61	49.21	53.25	74.08	94.91	106.26	127.45	196.95
	D.2.1. Iron ores and concentrates, iron and steel		1.32	1.64	2.04	2.53	3.14	3.89	4.82	5.98	7.42	9.20	11.41	47.86	66.09	84.32	68.17	95.97	126.97
	D.2.2. Non-ferrous metal ores and concentrates, processed metals		35.42	32.93	31.72	38.32	34.05	30.88	34.63	43.84	37.30	35.41	37.80	5.39	7.99	10.59	38.08	31.49	69.98
		D.2.2.1. Copper	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.2.2.2. Nickel	35.42	32.93	31.72	38.32	34.05	30.88	34.63	43.84	37.30	35.41	37.80	5.39	7.99	10.59	38.08	31.49	69.98
		D.2.2.3. Lead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.4. Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.5. Tin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.6. Gold, silver, platinum and other precious metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.7. Aluminium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.8. Uranium and thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.9. Other metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.2.3. Products mainly from metals		-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.3. Non metalic minerals primary and processed			48.35	99.71	151.07	226.95	242.55	283.01	321.66	353.54	392.73	429.02	458.81	399.20	364.49	342.57	369.20	211.71	221.48
	D.3.1. Ornamental or building stone		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.2. Limestone, gypsum, chalk, and dolomite		3.20	36.63	70.05	103.48	136.91	170.33	203.76	237.19	270.62	304.04	337.47	275.29	244.20	213.11	224.73	60.36	69.79
	D.3.3. Slate		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.4. Gravel and sand		45.15	63.08	81.02	123.46	105.64	112.67	117.89	116.35	122.12	124.98	121.34	123.91	120.29	129.46	144.47	151.35	151.69
	D.3.5. Clays and kaolin		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.6. Chemical and fertilizer minerals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.3.7. Salt		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.8. Other mining and quarrying products n.e.c.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.3.9. Excavated soil, only if used (e.g. for construction work)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.3.10. Products mainly from non-metalic minerals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.4. Fossil energy carriers, primary and processed			0.00	0.00	0.00	0.00	45.00	36.00	63.00	570.00	394.00	241.00	880.00	890.00	1,732.00	2,272.00	2,798.00	3,531.00	2,947.00
	D.4.1. Brown coal incl. oil shale and tar sands		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.2. Hard coal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.3. Petroleum		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,298.00	1,910.00	1,465.00
	D.4.4. Natural gas		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.5. Peat		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.6. Products mainly from fossil energy carriers		0.00	0.00	0.00	0.00	45.00	36.00	63.00	570.00	394.00	241.00	880.00	890.00	1,732.00	2,272.00	1,500.00	1,621.00	1,482.00
D.5. Other products			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.6. Waste exported for final treatment and disposal			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table D: Exports
units: 1,000 metric tons

1digit	2digit	3digit	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
D.1. Biomass and biomass products			7,089.08	7,952.81	7,776.73	8,090.21	7,769.65	6,921.39	3,978.68	3,515.58	2,831.03	4,196.64	3,829.11	2,767.33	3,240.28	3,731.48	3,104.36	3,270.88	1,950.69
	D.1.1. Primary crops		7,005.92	7,892.33	7,726.02	8,045.84	7,726.60	6,904.30	3,964.63	3,498.09	2,813.19	4,178.08	3,812.85	2,752.96	3,226.24	3,717.28	3,091.82	3,258.34	1,950.69
		D.1.1.1. Cereals, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	1.05	0.70	0.70	2.61
		D.1.1.2. Roots and tubers, primary and processed	18.77	17.32	9.93	5.00	1.50	1.00	0.30	0.00	0.72	3.85	0.00	0.00	0.06	0.11	0.67	0.68	0.67
		D.1.1.3. Sugar crops, primary and processed	6,397.65	7,262.67	7,206.59	7,554.38	7,334.43	6,619.54	3,812.01	3,412.65	2,730.15	4,099.10	3,727.58	2,681.39	3,115.58	3,584.50	2,967.40	3,180.40	1,862.59
		D.1.1.4. Pulses, primary and processed	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	7.77
		D.1.1.5. Nuts, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.1.6. Oil bearing crops, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.09	0.03	0.04	0.54
		D.1.1.7. Vegetables, primary and processed	9.12	8.59	8.60	8.70	8.70	8.70	8.70	8.70	8.70	8.50	8.50	8.20	0.47	0.63	1.22	0.78	0.71
		D.1.1.8. Fruits, primary and processed	536.09	560.72	458.67	432.45	338.45	251.25	123.25	55.95	51.25	43.45	52.85	38.45	88.24	105.52	93.08	46.03	44.79
		D.1.1.9. Fibres, primary and processed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.1.10. Other crops (Spices. Stimulant crops, Tobacco, Rubber...)	44.26	42.99	42.24	45.31	43.52	23.81	20.36	20.79	22.38	23.18	23.92	24.92	21.53	25.39	28.66	29.65	31.01
	D.1.2. Crop residues		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.2.1. n.a.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.2.2. Other crop residues (sugar and fodder beet leaves, other)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.3. Fodder crops incl. grassland harvest		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.3.1. Fodder crops	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.3.2. Biomass harvested from grassland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.4. n.a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.5. Wood primary and processed		50.00	26.61	21.21	21.21	21.23	2.23	2.19	2.27	1.90	0.98	0.41	0.41	0.41	1.48	1.48	1.48	0.00
		D.1.5.1. Timber, primary and processed	0.00	0.00	0.00	0.00	0.01	0.00	0.59	0.68	0.64	0.64	0.07	0.07	0.07	0.00	0.00	0.00	0.00
		D.1.5.2. Wood fuel and other extraction, primary and processed	50.00	26.61	21.21	21.21	21.21	2.23	1.60	1.60	1.26	0.34	0.34	0.34	0.34	1.48	1.48	1.48	0.00
	D.1.6. Fish capture, crustaceans, molluscs and aquatic invertebrates p.n.p		33.16	33.87	29.50	23.15	21.83	14.86	11.87	15.22	15.94	17.58	15.85	13.96	13.63	12.71	11.05	11.05	0.00
	D.1.7. n.a.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.8. Live animals other than in 1.6., meat and meat products		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.1. Live animals other than in 1.6.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.2. Meat and meat preparations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.3. Dairy products, birds eggs, and honey	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.1.8.4. Other products from animals (animal fibres, skins, furs, leather etc.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.1.9. Products mainly from biomass		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.2. Metal ores and concentrates, processed metals			155.67	199.81	141.27	399.64	255.25	203.42	149.41	95.98	140.95	191.36	222.36	237.86	249.12	323.32	260.37	315.35	241.16
	D.2.1. Iron ores and concentrates, iron and steel		104.90	74.03	58.58	97.00	27.65	50.87	71.90	93.51	133.39	143.04	150.61	154.39	141.83	197.11	154.95	173.30	151.11
	D.2.2. Non-ferrous metal ores and concentrates, processed metals		50.76	125.78	82.69	302.64	227.60	152.56	77.51	2.47	7.56	48.32	71.75	83.47	107.29	126.21	105.42	142.05	90.05
		D.2.2.1. Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		D.2.2.2. Nickel	50.76	125.78	82.69	302.64	227.60	152.56	77.51	2.47	7.56	48.32	71.75	83.47	107.29	126.21	105.42	142.05	90.05
		D.2.2.3. Lead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.4. Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.5. Tin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.6. Gold, silver, platinum and other precious metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.7. Aluminium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.8. Uranium and thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		D.2.2.9. Other metals	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.2.3. Products mainly from metals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.3. Non metalic minerals primary and processed			243.02	204.27	168.50	148.09	140.44	292.49	439.70	503.97	760.20	548.49	750.55	844.30	910.39	1,151.83	1,200.93	1,298.94	1,092.18
	D.3.1. Ornamental or building stone		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.2. Limestone, gypsum, chalk, and dolomite		86.99	54.83	14.18	9.25	5.93	165.35	378.35	438.03	680.78	479.81	667.10	760.75	854.39	1,041.68	1,135.32	1,228.97	1,021.48
	D.3.3. Slate		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.4. Gravel and sand		156.03	149.44	154.32	138.84	134.51	127.14	61.35	65.94	79.42	68.68	83.45	83.55	56.00	110.15	65.61	69.98	70.70
	D.3.5. Clays and kaolin		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.6. Chemical and fertilizer minerals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.3.7. Salt		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	D.3.8. Other mining and quarrying products n.e.c.		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.3.9. Excavated soil, only if used (e.g. for construction work)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.3.10. Products mainly from non-metalic minerals		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.4. Fossil energy carriers, primary and processed			3,150.00	2,839.00	2,717.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.1. Brown coal incl. oil shale and tar sands		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.2. Hard coal		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.3. Petroleum		1,232.00	1,080.00	1,080.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.4. Natural gas		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.5. Peat		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	D.4.6. Products mainly from fossil energy carriers		1,918.00	1,759.00	1,637.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.5. Other products			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D.6. Waste exported for final treatment and disposal			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9.4. Curriculum Vitae

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Persönliche Daten

Geburtsdatum	16. März 1982
Geburtsort	Havanna, Kuba
Staatsbürgerschaft	Österreich
Religion	römisch-katholisch
Familienstand	ledig

Schulbildung

1988-1990	Volksschule Diesterweggasse, Wien XIV
1990-1992	Volksschule Meißnergasse, Wien XXII
1992-2000	Bundesgymnasium Bernoullistraße, Wien XXII
2001-2002	Dialogica-Akademie, Wien X

Akademische Laufbahn

September	2002	Individuelles Diplomstudium Internationale Entwicklung an der Universität Wien (A)
Januar – April	2006	Praktikum am IFF Wien, Institut für Sozialökologie an der Universität Klagenfurt (A)
Januar – Juni	2007	Erasmus Stipendium an der Universidad de Granada (ES)
Februar	2009	Diplomprüfung

Diplome und Zertifikate

Januar	2002	London Chamber of Commerce Certificate
Juni	2002	Marketing Business Certificate
Juni	2002	Bürozertifikat der Wirtschaftskammern
Mai	2002	ECDL European Computer Driving Licence

Sprachkenntnisse

Englisch, Portugiesisch, Spanisch, Französisch

Wien, Januar 2009