Akademien der Wissenschaften Schweiz
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Measuring the use of natural resources and its impacts

Indicators and their application

Glossary

Indicator	An indicator is a variable based on measurements, representing as accurately as possible and necessary a phenomenon of interest (Joumard and Gudmundsson 2010). A number of different systems have been developed for classifying indicators, such as the Driving Forces, Pressures, States, Impacts, Responses (DPSIR) system (Gabrielsen and Bosch 2003).
Natural resources	Resources which occur in nature. These include renewable and non-renewable primary raw materials, physical space (land area), environmental media (water, soil, air), flow resources (such as geothermic, wind, tidal and solar energy) and biodiversity. Here it is unimportant whether the resources serve as sources for the manufacture of products or as sinks for the absorption of emissions (water, soil, air) (German Federal Environment Agency UBA 2012, with reference to the thematic strategy for sustainable use of natural resources by the EU).
Life Cycle Assessment	A process to evaluate the environmental burdens associated with a product system or activity, by identifying and quantitatively describing the energy and materials used, and wastes released to the environment. The consequent assessment of the associated impacts includes the entire life cycle of the product or activity, encompassing extracting and processing raw materials, manufacturing, distribution, use, re-use, maintenance, recycling and final disposal, and all transport involved. LCA addresses environmental impacts in the areas of ecological systems, human health and resource depletion (Fullana et al. 2009, S. 26).

Foreword

Given that our human living space – the Earth – is finite, and that the global consumption of natural resources has clearly grown in the past few decades, the question of how we can deal with our natural resources better, i.e. more sustainably, is becoming increasingly urgent – not least because the use of natural resources necessarily has considerable effects on the environment.

A basic precondition for the better use of natural resources is knowledge. Science can play an important role by making the effects of the use of natural resources measurable and therefore comprehensible and by interpreting the results of application of these indicators.

This brochure gives an overview of possible indicators for assessing the use of natural resources and shows where there are still gaps. These will have to be closed, in a combined effort between science, politics and other players, if we seriously aim to bring about a transformation to a more sustainable society. A more sustainable handling of finite natural resources is not merely a question of ecology versus economy, but also encompasses social, cultural, moral and political aspects. This brochure deliberately restricts itself to the physical world. It is conceived as an introduction to the theme.

Prof. Dr. Ulrich W. Suter
SATW President

Dr. Xaver Edelmann
World Resources Forum

Indicators as an aid to decision making

Natural resources such as materials, water, land area and energy are essential for all life – and they are finite. Humans are also dependent upon them for their individual metabolism and for their economic activities.

While a human in a hunter-gatherer society required around 3 kilograms of biotic and abiotic material a day, the consumption of a present-day human in an industrial country lies at more than 40 kilograms per day (Fischer-Kowalski et al. 1997). The growing consumption of resources per capita and the rapid growth of the world population is increasing the pressure on the Earth's ecosystem and could become a burden for future generations. It is noticeable that there is a growing awareness of the finiteness of natural resources today, for example in the case of oil, metals or the water supply in dry regions.

Must we limit our consumption? Or can we combat the scarcity of natural resources through technological advances and greater efficiency alone? It is up to society to decide how it should use natural resources, and whether it wishes to handle them more consciously and sustainably (see for example SATW paper no. 41 "Rare metals: raw materials for technologies of the future"). If society is willing to pursue this path resolutely, it must however quantify and measure the use of natural resources and the problems associated therewith, for example by means of indicators.

A number of different indicators have been developed in recent years. These differ among other ways in what they reveal (use of resources and/or associated effects) and in the extent to which they take account of qualitative aspects of the resource requirement (for example the nature of the use of land area or types of materials). The determining factor for their practical application will be whether they are "for all remaining uncertainty, of the correct order of magnitude, and whether they steer those using them in the right direction" (Schmidt-Bleek 2007); that is whether they are directionally safe and how representative, applicable, reliable, transparent, accessible and comprehensible they are.

In this brochure selected indicators for measuring and quantifying the use of resources and their effects are presented. The brochure describes indicators relating to the resource categories materials, land area, energy and water, and examines these using as an example four metals which play an important role in the manufacture of high tech products (see table): copper (Cu), platinum (Pt), lithium (Li) and neodymium (Nd). A decisive factor in the calculations for the respective indicators is that they include all the material and energy flows throughout the life cycle of a product or service. For the metals examined in this brochure, all material and energy flows occurring from the extraction of the raw material to the marketable metal are taken into account (see Figure 1). The necessary data are taken from the data base ecoinvent (2010), developed specifically for calculating life cycle assessments[1].

Materials	**Land area**
Water	**Energy**

The resource categories covered by each indicator are marked in the relevant colours in the brochure.

	Metal category	**Applications (selection)**	**Annual production in tonnes, 2010 (USGS 2011)**
Copper	Semi-noble metal	Electrical wires, copper pipes	16 200 000
Lithium	Alkaline metal	Batteries, medicines, lubricant additive, cement additive	25 300
Neodymium[2]	Rare earth metal	Permanent magnets, lasers	-[3]
Platinum	Noble metal	Vehicle catalytic convertors, laboratory equipment, tooth implants, jewellery	183

Table 1: Applications and annual production of the four selected metals.

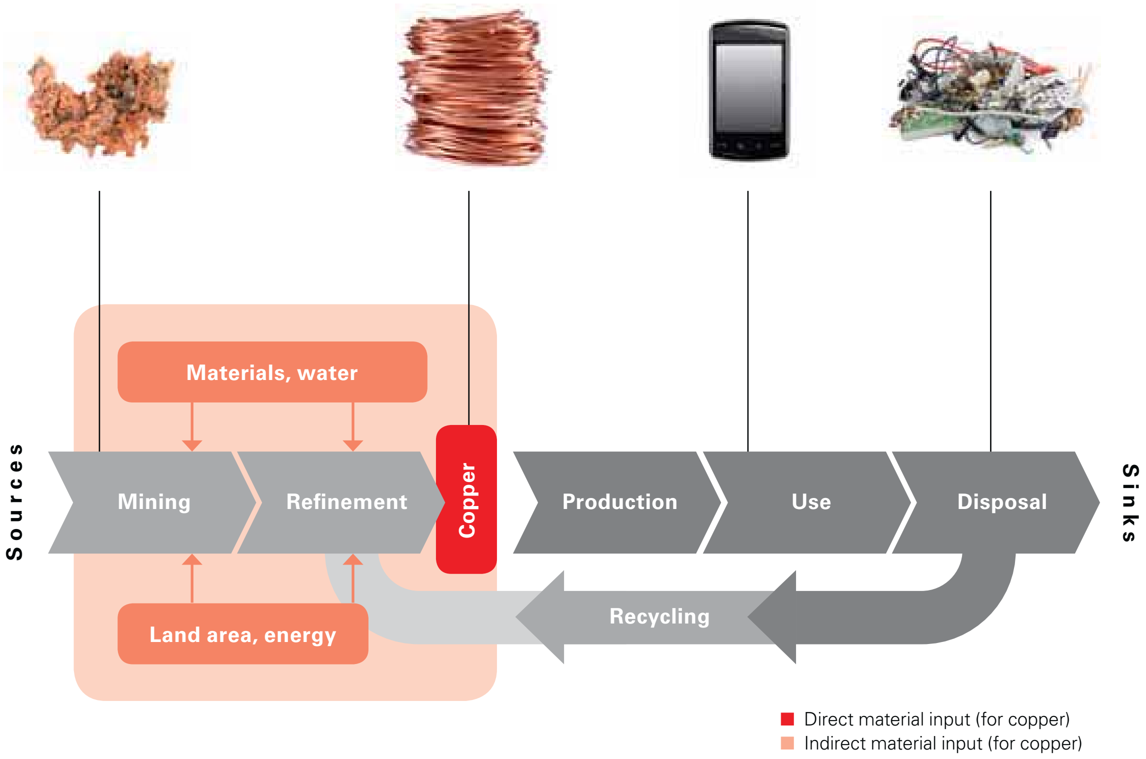

Figure 1: Resource inputs and life cycle stages; shown using copper as an example.

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[1] Details of the calculations can be found in the data sheets on the four metals on the website www.ecoinvent.ch.

[2] Because in ore mining neodymium is one of several by-products in the mining of monazite and bastnaesite, only 41% of the total environmental impact is allotted to it in the calculations.

[3] The annual production of neodymium is not shown separately. The groups of rare earths together amount to 130,000 tonnes.

Materials

The total volume of biotic and abiotic material mined and integrated into products and services in 2007 is estimated at around 60 billion tonnes (SERI 2010). This volume rises to 120 to 180 billion tonnes when the unused material is also taken into account. Existing indicators for the use of materials record and measure the nature and volume of the materials but do not generally describe the diverse environmental burdens associated with these.

The greater the volume of material extracted, the graver the impact on the ecosystems. This notion gives rise to the metaphor of the "ecological rucksack". According to its definition the ecological rucksack includes all material flows required for the manufacture of a product. The product's own weight is not taken into account (Schmidt-Bleek 1994). In terms of what it conveys about environmental burdens the concept is simplifying, as the material flows are recorded only quantitatively; qualitative material properties such as the toxicity of a material are disregarded. Despite this simplification, the ecological rucksack method forms the basis for a range of indicators (for example MIPS (Material Input per Service unit), TMR (Total Material Requirement), DMI (Direct Material Input)). The main difference between the individual indicators lies in the chosen system boundaries: depending on the range selected the indicators focus either on the macro level (for example TMR for countries, national economies) or on the micro level (for example MIPS for services), and take account of material categories to a greater or lesser extent.

MIPS

The indicator "Material Input per Service Unit" (MIPS) measures the consumption of materials required for a service. Seen from this perspective, products are "service producing machines" (Schmidt-Bleek 2007). The MIPS takes account of five types of material categories:

- Abiotic materials; including mineral raw materials, fossil fuels and excavated earth,
- Biotic materials,
- Earth movement in agriculture and forestry, including erosion,
- Water from surface water, ground water and deep water, and
- Air in connection with combustion processes and chemical or physical conversion.

The MIPS records direct and indirect material inputs (see Figure 1, page 5). For a product this means own weight plus rucksack. The material input is defined as the total volume of material that is moved over the whole life cycle of the product. Within the MIPS concept, the term "material" also includes fossil fuels, water and air. The bases for calculation of the MIPS are provided by the Wuppertal Institute for Climate, Environment and Energy (Wuppertal Institut 2011).

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[4] More information on the indicators TMR and DMI can be found at the following web address: http://www.eea.europa.eu/publications/signals-2000/page017.html.

According to the MIPS the production of one kilogram of platinum consumes around 530 tonnes of material (Figure 2, red bars). The value for one kilogram of copper is nearly three orders of magnitude lower (0.7 tonnes). No MIPS values are available for lithium and neodymium.

Comparison of the two MIPS values with a total material volume calculated additionally according to ecoinvent data (Figure 2, blue bars) shows that the results are of a similar magnitude. The MIPS values, which unlike the total material volume also include the product’s own weight, exhibit higher material volumes. This can be attributed mainly to the fact that the MIPS value together with the abiotic and biotic materials also takes account of the resources water and air.

The strength of the MIPS is that it is easily comprehensible and simple to apply. Its weakness is that the great extent to which it simplifies. Thus different materials are grouped together in a single parameter. By disregarding the qualitative aspects, ultimately the MIPS does not give a differentiated image of the environmental burdens accompanying the use of the material.

Materials	**Land area**
Water	**Energy**

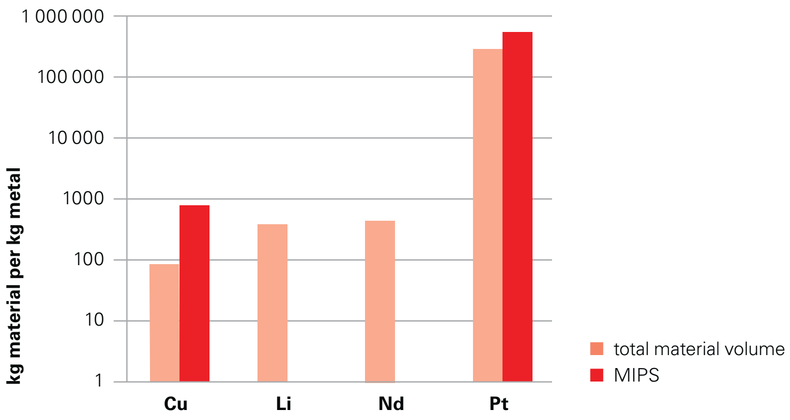
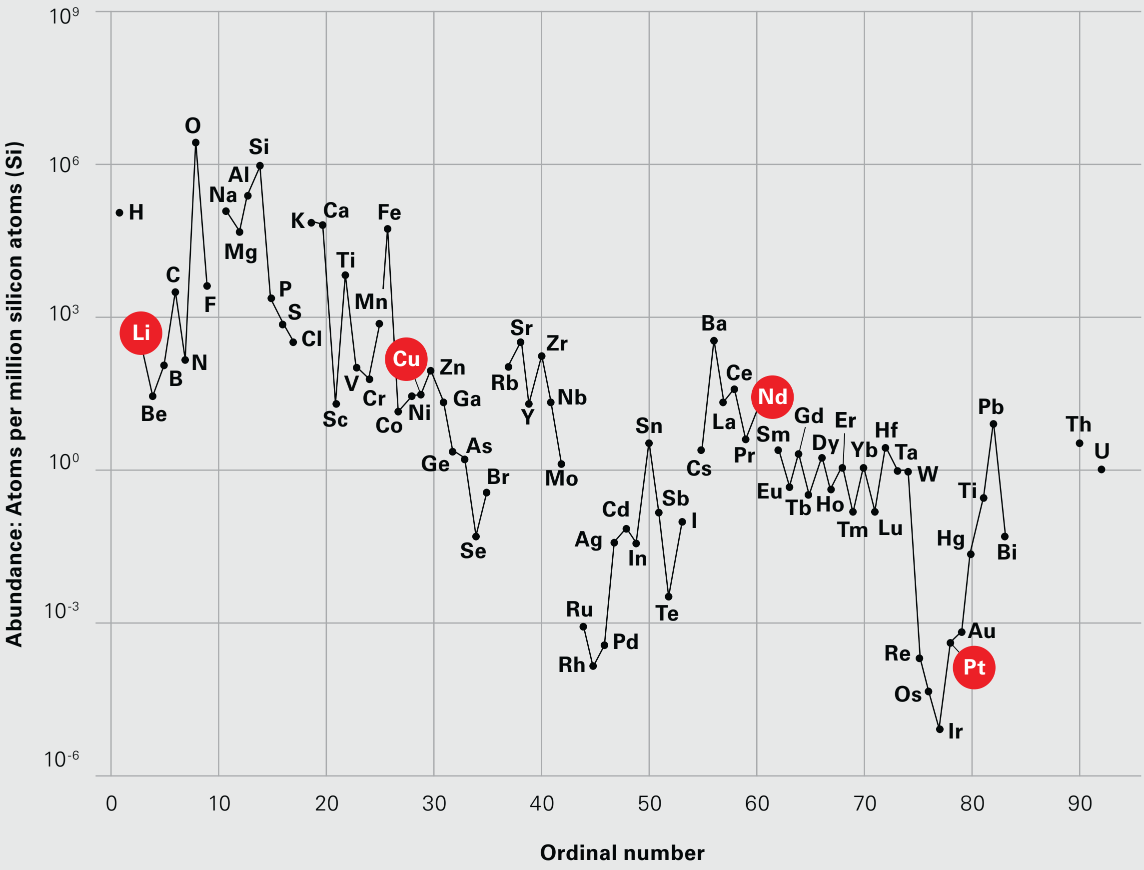


Figure 2. Comparison between MIPS (red, data from Wuppertal Institut 2011) and the total volume of indirectly consumed materials (light red) according to ecoinvent (2010); logarithmic representation. MIPS values are not available for lithium and neodymium.

Abundance of elements in the Earth's upper crust



The figure shows the abundance of various elements in the Earth's upper crust as the number of atoms per million silicon atoms. Of the four metals considered in the brochure (indicated with red dots), lithium is the most abundant, followed by copper and neodymium, which are one and two orders of magnitude rarer respectively. One of the rarest metals is platinum. With the indicators used in this brochure the more abundant metals (Cu, Li, Nd) perform better in terms of consumption of natural resources and environmental impact caused. (Source: Wikipedia, adapted according to USGS (2002), Rare Earth Elements, Critical Resources for High Technology)

Land area

The land area of the Earth measures just under 150 million km^2, corresponding to around 30 per cent of the Earth's total surface area. Pressure on the resource of land is increasing through the human needs of a growing world population such as mobility, food, living and recreational space of a growing world population. An easily applicable instrument is therefore required to quantify the area consumption for products and surfaces.

The mining of raw materials such as ores requires land. Intervention in an area of land leads to greater or lesser environmental impact depending on specific characteristics such as vegetation, soil condition or type of use. For instance it makes a great difference to the impact on biological diversity and the output of the ecosystem (such as the production of biomass) whether copper is mined in rainforest or in a desert. Therefore a purely quantitative summing up of the area used does not go far enough from an ecological point of view. An evaluation of the land area in terms of its qualitative characteristics is also required. Two existing methods are described briefly below: the Ecological Footprint, which is widely used, and a typical land area indicator developed in connection with Life Cycle Assessment.

Ecological Footprint

The Ecological Footprint was developed in the 1990s by Mathis Wackernagel and William Rees and is today a widespread international method for representing the use of natural resources (Wackernagel et al. 2005). It expresses the biologically productive area that is required for example for the activities of an individual or within a country over a particular period in order to generate all the products and services consumed and to absorb the incidental waste. The unit of measurement is the global hectare (gha), which describes the average productivity of the biologically productive Earth surface per hectare in one year. If the method is applied to geographical areas, not only can the use of resources be estimated but these can also be compared with the corresponding available capacity of natural resources.

The Ecological Footprint records the land consumption for the following types of use: agriculture, pasture, fishing grounds, commercial timberland and built land (directly calculated land use). For each type of use the method provides a factor for converting the respective temporally and spatially varying productivity into a comparable unit (the global hectare). As a sixth type of use a virtual "CO_2 area" has been introduced. "CO_2 area" represents the area of ocean and forest that would be required to rebind the volume of carbon dioxide released in the use of fossil fuels (indirectly calculated land use). The "CO_2 area" proportion of the global land consumption is significant: in 2007 it was around 50 per cent.

Calculation of the Ecological Footprint of the worldwide production of copper, lithium and platinum in 2010 shows that overall copper consumes significantly more resources (in global hectares) than platinum and lithium (see Figure 3). The picture looks different, however, if the impact of the production of one kilogram of each metal is calculated: the land use (in global hectares times years[5]) is of an order of magnitude three to four times higher for platinum than for copper, lithium and neodymium (see Figure 4).

In the case of all the metals studied, by far the biggest share of land consumption and/or land use is attributed to compensation for the consumption of fossil fuels (CO_2 area). An important role is also played by the land area for compensating the consumption of nuclear energy, which is also shown in the Life Cycle Assessment data base used[6].

Materials	**Land area**
Water	**Energy**

The Ecological Footprint has become established as a method in recent years. Its great strength is its intuitive accessibility. Still, the method requires a certain ability for abstraction, as it differentiates between directly and indirectly calculated land areas, for example.

Land area indicator in ReCiPe

ReCiPe is a comprehensive assessment method for Life Cycle Assessment, which combines several indicators to estimate various environmental burdens (Goedkoop et al. 2009). One of the indicators used in ReCiPe describes the environmental burden arising through the use of an area of land by calculating the potential fraction of species lost through this use (measured as species times year) (De Schryver and Goedkoop 2009). The basis for calculation of the loss of species is the land use, which is defined not only by type of use and area but also by duration of use. The unused land area serves as a reference. ReCiPe is used as a method worldwide, although to date the land area indicator is based only on data on plant diversity from types of land use in Great Britain.

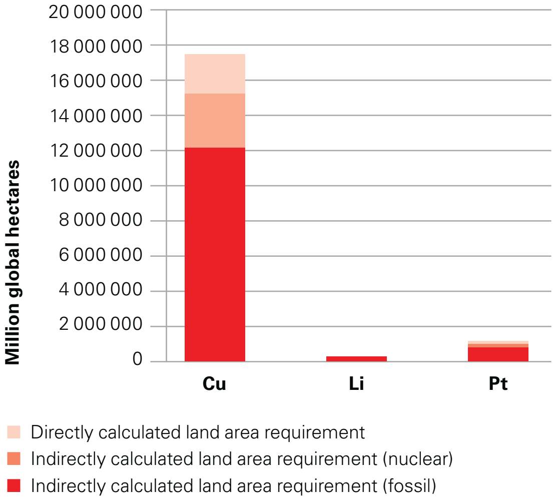


Figure 3. Ecological Footprint in million global hectares for the total worldwide production (see Table 1) of the metals copper, lithium and platinum in 2010 (data taken from ecoinvent (2010)). No specific figures on annual world production are available for neodymium.

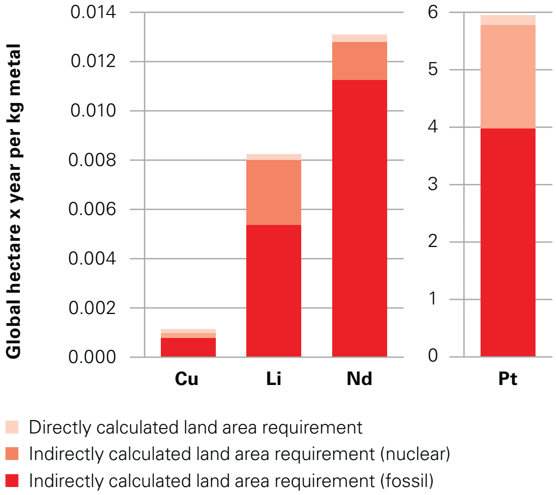


Figure 4. Extent of land use associated with the production of one kilogram of each metal
(Data taken from ecoinvent (2010)).

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[5] This unit results from the fact that the method of the ecological footprint is oriented towards one activity per period of time (year), while here however a time independent reference value (1 kg metal) is used.

[6] As with fossil fuels, in the implementation of the Ecological Footprint in the ecoinvent life cycle inventory data base the consumption of nuclear energy on an area was also represented. For this the volume of nuclear generated energy was converted into an equivalent fossil fuel volume via the energy density of fossil energy sources (megawatt hours per kilogram).

As can be seen from Figure 5, the calculated potential loss of species from the production of copper and lithium works out at around the same level, while the level for neodymium is one order of magnitude higher[7]. The values for platinum on the other hand exceed the other metals by two to three orders of magnitude.

Materials	**Land area**
Water	**Energy**

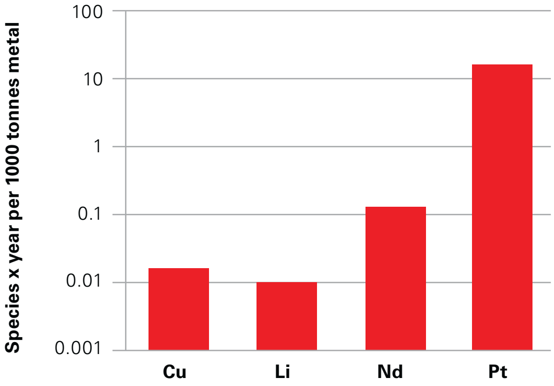

Figure 5 shows the loss of species that can be attributed to the production of each of the four metals (logarithmic representation, data taken from ecoinvent 2010).

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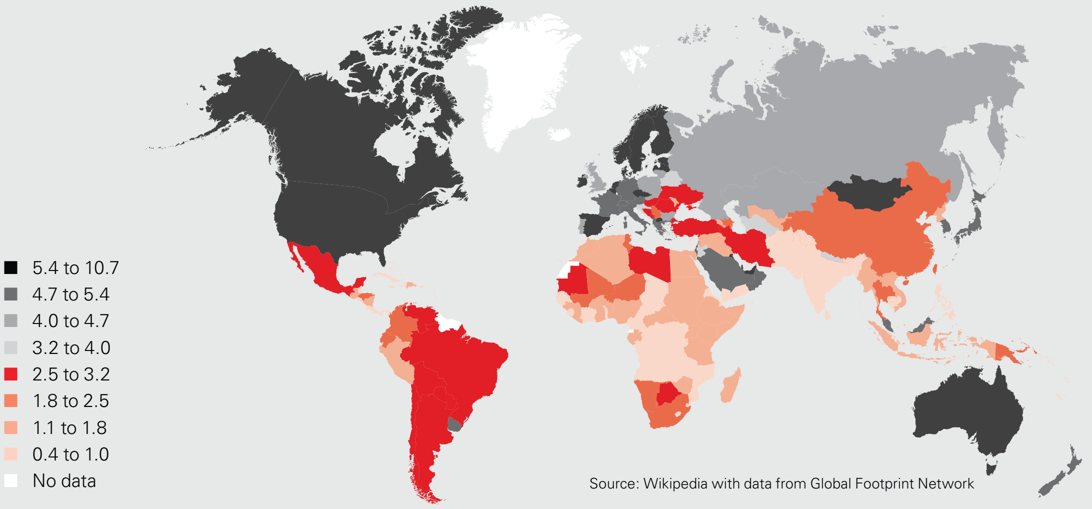
[7] The ReCiPe land area indicator is implemented in ecoinvent.

Ecological Footprint per person in 2007 (in global hectares)



Source: Wikipedia with data from Global Footprint Network

Over one year a human consumes a certain average number of products and services. The Ecological Footprint describes how many hectares of biologically productive land are required to produce these. In 2007 the Ecological Footprint per person worldwide was 2.7 global hectares (gha).

The biocapacity, however - that is the capacity of ecosystems to produce biologically useful materials and to absorb the waste produced by humans under present conditions - was only 1.8 gha. Thus humans are today consuming 1.5 planets; in other words, it takes the Earth around one year and six months to cover the consumption of humanity for one year.

The biggest Ecological Footprint was recorded by the United Arab Emirates in 2007 at nearly 11 gha per person. Switzerland “consumes” 5 gha per person, China 2.2 gha and India around 1 gha.

Energy

Today around 80 per cent of the global energy consumption is covered by fossil fuels (IEA 2010). Carbon dioxide (CO2) emissions prove to be a suitable indicator for determining the environmental burden caused by the use of fossil energy sources. In 2007 the total anthropogenic CO_2 output according to IPCC[8] amounted to 31 gigatonnes, or a good 4 tonnes of CO_2 per person. The IPCC's "100-year Global Warming Potential" method has become established as the standard for estimating the greenhouse effect.

The carbon dioxide emitted during the combustion of fossil fuels is responsible for just under 60 per cent of all anthropogenic greenhouse gas emissions. The remaining 40 per cent consist of carbon dioxide from other sources, methane, nitrous oxide, chloro-fluorocarbons and other greenhouse gases (IPCC 2007a). Consequently energy consumption is closely linked with the climate issue. As an indicator for energy consumption the "Global Warming Potential 100 years" (GWP 100 years) method provides a good basis as it decribes, amongst others, the greenhouse potential of the CO_2 emissions (IPCC 2007b).

100-year GWP

The "GWP 100 years" method describes the extent of the climate effect of a particular volume of a greenhouse gas over a period of 100 years. The greenhouse potential of one kilogram of carbon dioxide serves as a reference value, and for this reason the average climate effect of all other greenhouse gases is expressed in CO_2 equivalents (CO_2e). For methane for example the IPCC gives a CO_2 equivalent of 21. This means that the emission of one tonne of methane considered over 100 years has the same greenhouse effect as the emission of 21 tonnes of carbon dioxide. If as here the focus is on the issue of energy, however, then only the CO_2 emissions are of interest.

Carbon dioxide makes up over 90 per cent of the total greenhouse emissions from the production of the four metals (Figure 6). Platinum has a CO_2 output of just under 15 tonnes per kilogram of metal, that is three to four orders of magnitude higher than the volumes of emissions from copper, lithium and neodymium. It is striking to note that the CO_2 emissions per kilogram of copper, at 2.8 kilograms, are around one order of magnitude lower than those from lithium, while these on the other hand are around half as great as those from neodymium.

The "GWP 100 years" method is well validated scientifically and used worldwide, and its application is becoming increasingly strongly standardised (for example by means of the British standard PAS 2050[9]).

Materials	**Land area**
Water	**Energy**

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[8] Intergovernmental Panel on Climate Change; see http://www.ipcc.ch/.

[9] More detailed information on the standard can be found at http://www.bsigroup.com/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050.

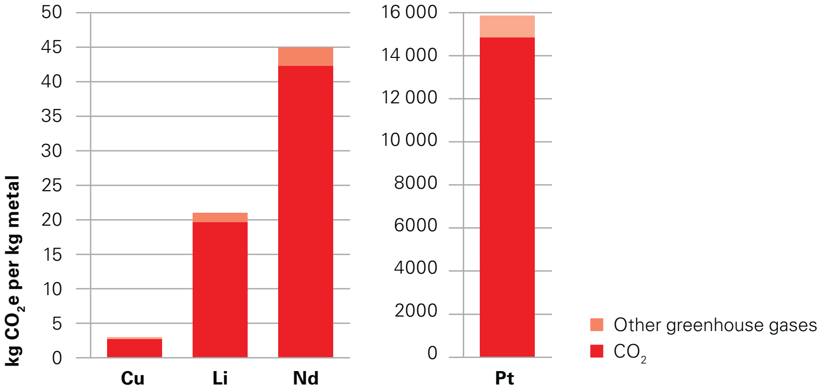
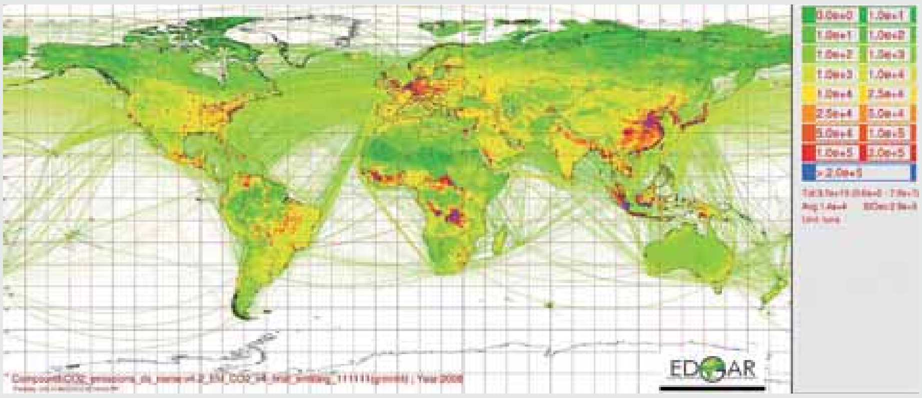


Figure 6. Greenhouse gas emissions as CO_2 equivalents (CO_2e) per kilogram of metal produced according to the IPCC's "100-year GWP" method (2007b). Data from ecoinvent (2010).

Where is carbon dioxide being emitted and in what volumes?



Source: European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), release version 4.2. http://edgar.jrc.ec.europa.eu, 2011.

The map shows the global anthropogenic CO_2 emissions for 2005, as calculated by the European research project EDGAR[10]. Certain areas in North America, Western Europe, China and Japan stand out, showing a CO_2 output of more than 50,000 tonnes per year and cell over a large area (as a comparison: in Switzerland the CO_2 output per capita in 2009 was approximately 5.6 tonnes[11]). One cell measures 0.1° x 0.1°, corresponding to approximately 10 km x 10 km. The map also clearly shows the emissions caused by maritime freight traffic.

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[10] The EDGAR research project (http://edgar.jrc.ec.europa.eu/index.php) calculates the emissions of various anthropogenic pollutants, spatially resolved. These are calculated using spatial data on population density, maritime and terrestrial transport systems, agriculture etc.

[11] These and other figures on greenhouse gas emissions in Switzerland can be found at http://www.bafu.admin.ch/umwelt/status/03985/index.html?lang=en.

Water

Based on estimates the current global fresh water use lies at 2600 cubic kilometres and the proposed upper use limit at 4000 cubic kilometres per year (Rockstrom et al. 2009). Regardless of this apparent "water reserve", the availability of water all year round is already no longer guaranteed in various regions of the Earth today. Appropriate indicators to describe the use of water and the effects thereof are still under development.

As with the land area indicators, it is also crucial for water indicators to describe the effects of use of the resource correctly. This is achieved using criteria that go beyond a simple data gathering of the amount, such as water pollution, water availability or origin of the water.

In past years a number of different initiatives have been launched to develop and establish suitable indicators for determining water use and the effects thereof[12]. Some concepts and indicators are currently still under development, while the possibilities for application of existing indicators are still limited at present.

Water Footprint

One of the most well-known indicators is the water footprint by Hoekstra et al. (2011). This is an indicator for fresh water use. The reference value is the water volume, to calculate and describe which the indicator covers several quantitative and qualitative dimensions:

- Direct and indirect water use: account is taken of volumes of water found directly in the product, and also indirect flows ("virtual water"). According to this method, a one-litre bottle of mineral water not only contains the mineral water itself (direct water use), but water is also used for example for cleaning the bottle (indirect water use).

- Water consumption (quantity) and water pollution (quality): three types of water are differentiated. Green water refers to rain water, blue water to surface or ground water which has evaporated, is contained in the product or has been extracted from the catchment area in question. Grey water describes the degree to which the water is polluted and symbolises the volume of water required to dilute the contaminated water so that a given limit value is met.

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[12] See for example the ISO study group on the water footprint (see http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=43263) or the UNEP/SETAC WULCA study group (Water Use and Consumption in Life Cycle Assessment) (see http://lcinitiative.unep.fr/sites/lcinit/default.asp?site=lcinit&page_id=2AAEA21D-4907-4E16-BF28-A63C072B6BF7).

In order to assess how critical the use of a certain volume of water is for a region (for example for the catchment area of a stream), this volume is compared with the water available. Because both figures are subject to variation, these must be recorded with their temporal and spatial details.

The indicator has been applied initially to agricultural products and national economies. Specific data are not yet available for industrial production and for mining. Thus here it is only possible to show the total direct and indirect water input for production of the metals according to ecoinvent (see Figure 7). The production of one kilogram of copper, lithium or neodymium requires around 100 cubic metres of water in each case. The production of one kilogram of platinum on the other hand consumes a volume of water three orders of magnitude higher (90,000 m^3).

Although the methodological bases for indicators for water use exist, their application in areas such as industrial production often fails due to gaps in the data, for example for mining. Existing LCA data bases do not include detailed water data. This, however, will change with the new version of ecoinvent, ecoinvent 3.0.

Materials	**Land area**
Water	**Energy**

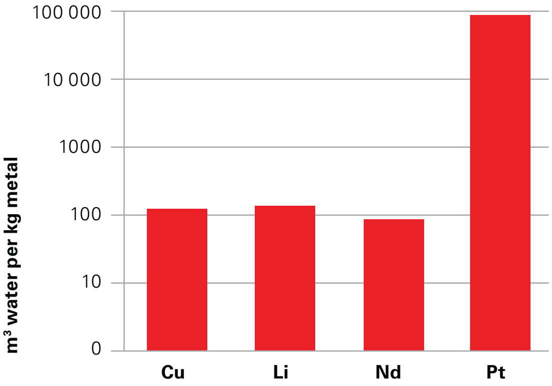
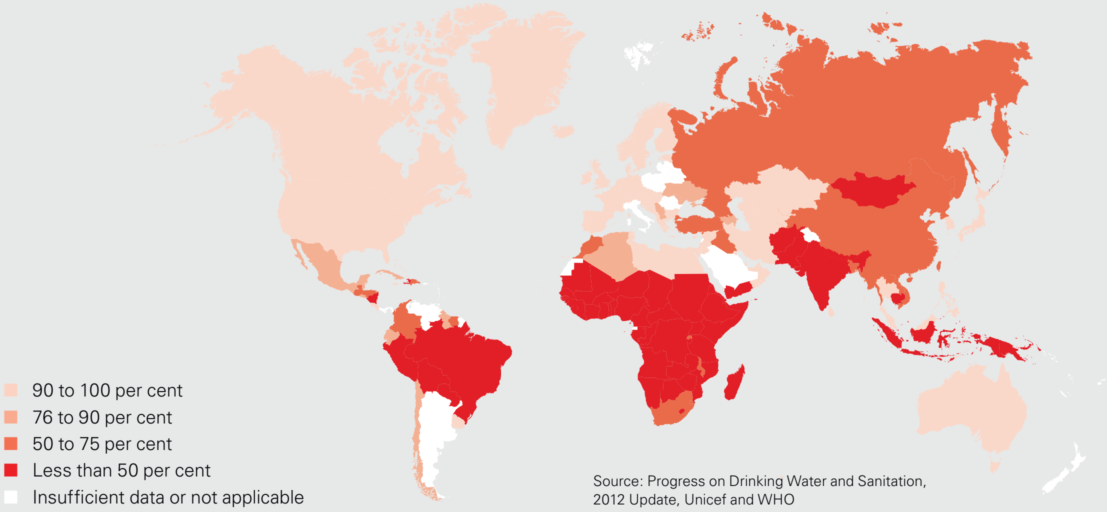


Figure 7. Logarithmic representation of the volume of water required according to ecoinvent (2010).

Sanitation in rural areas



Source: Progress on Drinking Water and Sanitation, 2012 Update, Unicef and WHO

Access to clean water and sanitation is an important factor for human health and hygiene. In many developing countries less than 50 per cent of the rural population have access to sanitation (numbers as of 2010).

Conclusion

The more intensive and more global the human interventions in nature are, the more complex and uncertain the interactions between humans and the environment become. Suitable indicators help us to understand and assess the effects of human actions in order ultimately to find measures for a more sustainable governance of the environment.

In this brochure current methods and indicators for the four natural resource categories materials, land area, energy and water are presented and – as an example of how they are used – applied to the production of one kilogram each of the metals copper, lithium, neodymium and platinum from primary resources. Application of the indicators to the four above metals led to similar rankings in terms of the consumption of resources and impact on the environment. By far the biggest consumption of resources and environmental impact is associated with the production of one kilogram of platinum. On the other hand, if the annual world production of the respective metals is considered (see Table 1 on page 5) – as shown for example by the Ecological Footprint – it is the production not of platinum but of copper which entails the biggest consumption of resources and/or environmental impact (see also Hertwich et al. (2010)).

Basically when considering indicators for assessing the use of natural resources, the following must be taken into account: each of the indicators focuses on a different aspect of the reality, as if the viewer is looking through spectacles with differently coloured lenses. Moreover they rely on differing methods with specific assumptions and simplifications, as a result of which they meet the requirements regarding validity, representativeness, reliability, directional safety, transparency, accessibility, comprehensibility and applicability to varying extents (see for example Wäger et al. (2010)).

The **MIPS** indicator records only the material consumption and not its effects on the environment. The idea of the **“ecological rucksack”** upon which it is based is easy to interpret and the indicator is relatively simple to apply. However, MIPS must not be understood as a global indicator for the environmental impact of the material consumption.

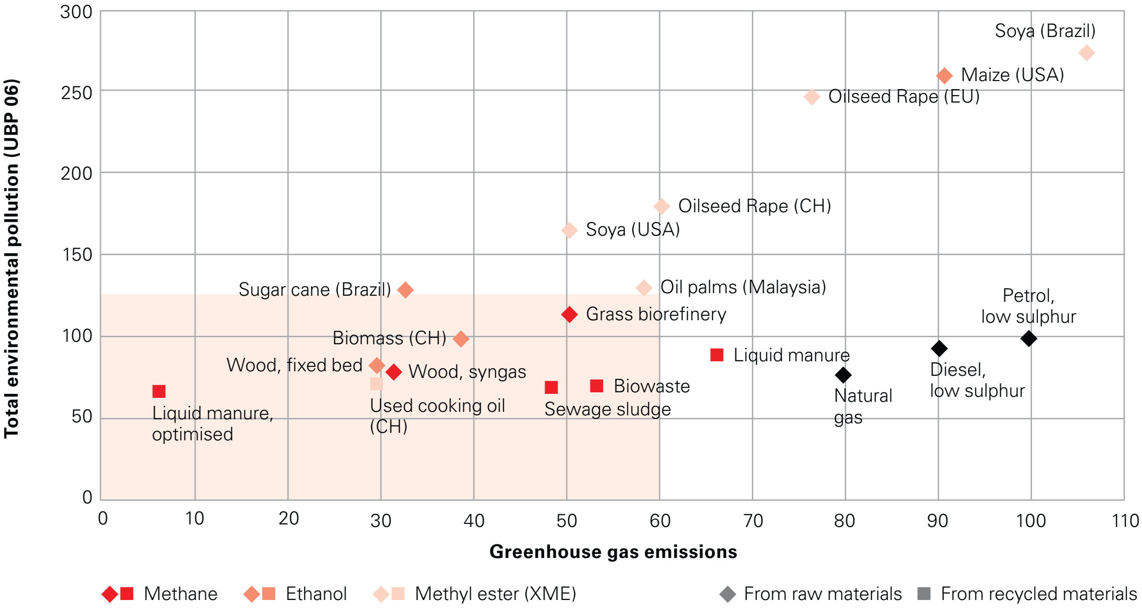
The **Ecological Footprint** takes account of renewable resources, expressed as the use of biologically active land area. One major advantage of the metaphor of the footprint is that it is intuitively accessible to a wide public. Applied to regions and countries it gives a good picture of temporal developments. Nevertheless, the method requires a certain ability for abstraction, as it differentiates between directly and indirectly calculated land areas, for example. Land area required to offset CO_2 emissions accounts for around 90 per cent or more of the results for the four metals examined.

The land area indicator in the **ReCiPe evaluation method** specifically developed for calculating Life Cycle Assessments explicitly describes the environmental impact of loss of biodiversity through land use. The data on which the method is based are geographically limited, which casts doubt upon its worldwide application. In the absence of alternatives Life Cycle Assessment experts frequently resort to using the ReCiPe land area indicator – and take its weaknesses into account.

The purpose of the **“100-year GWP”** is to estimate the global warming potential of greenhouse gases over a period of 100 years. Because the indicator is standardised on CO_2 emissions, it is frequently used specifically for fossil fuel use. The “100-year GWP” measures only the fossil fuel part and not the renewable part. The method is very well validated scientifically, reliable and easy to apply.

The **Water Footprint** indicator addresses the volume of consumed water and polluted water. The purpose of the indicator is to assess the availability of water in catchment areas. While the indicator is easy to comprehend, the environmental impacts are only implicitly included (as “grey” water). Due to a lack of data it is not yet possible to apply it for example in the mining sector.

The indicators described in this brochure are already in use in decision making processes. The “100-year GWP” for example found practical application in Swiss legislation[13] on the taxing of fuels. According to the Mineral Oil Tax Ordinance, fuels derived from renewable raw materials (biofuels) are exempt from mineral oil tax, provided that they meet certain sustainability criteria. The first criterion for tax exemption is that a biofuel must cause at least 40 per cent fewer greenhouse gas emissions compared to petrol from its cultivation to its consumption. The two other criteria are that a biofuel must not cause significantly more environmental pollution than fossil petrol from cultivation to consumption (<125%[14]) and that it must not threaten the conservation of the rainforests or biodiversity. This legislation was based on a study commissioned by several Swiss Federal Offices in which existing biofuels were subjected to ecological assessment (Zah 2007).



Source: Empa

Figure 8. Greenhouse gas emissions and environmental pollution from biofuels compared to petrol. Fuels in the area underlaid in red meet the minimum requirements for mineral oil tax exemption, for greenhouse gas emissions and also for total environmental pollution.

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[13] More detailed information can be found in the Mineral Oil Tax Law (MinöStG), the Mineral Oil Tax Ordinance (MinöStV) and the Ordinance on Fuel Life-Cycle Assessment (TrÖbiV).

[14] This evaluation was made using the Ecological Scarcity method (UBP) method developed in the context of Life Cycle Assessment (see http://www.bafu.admin.ch/dokumentation/umwelt/08880/08908/index.html?lang=en)

It is not only politicians who make use of the indicators for the use of natural resources. The spectrum of users today extends from individuals (for example in purchase decisions) and companies (for example in improving production processes) to nations or international communities of states (for example in political decisions as to whether to promote new technologies).

Users of an indicator must be aware that methodologically each indicator has its own strengths and weaknesses and/or possibilities and limitations. For the selection of a suitable indicator or combination of indicators, ultimately the determining factor in each case is the specific application context. An important precondition for appropriate selection is in every case an informed and precise definition of the goals that we want to achieve on the way to a more sustainable use of natural resources.

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