Swiss Ecological Scarcity Method: The New Version 2006

Rolf Frischknecht[1], Roland Steiner[1], Braunschweig Arthur[2], Egli Norbert[3], Hildesheimer Gabi[4]
[1] ESU-services GmbH
Kanzleistrasse 4, CH-8610 Uster, Switzerland
frischknecht@esu-services.ch, steiner@esu-services.ch
[2] E2 Management Consulting AG
Wehntalerstrasse 3, CH-8057 Zurich, Switzerland
abraunschweig@e2mc.com
[3] Swiss Federal Office for the Environment (FOEN)
CH-3003 Berne, Switzerland
norbert.egli@bafu.admin.ch
[4] oe b u
Obstgartenstrasse 28, CH-8035 Zurich, Switzerland
hildesheimer@oebu.ch

Keywords: keywords

ABSTRACT

The Swiss Ecological Scarcity method has first been introduced in 1990 and updated in 1997. Currently the Swiss version of this method is updated and extended. The update and extension of the method takes into account the recent developments in Swiss and European (as far as it is relevant for Switzerland) legislation and environmental targets. Furthermore, ISO standard revisions and recent developments in scientific knowledge on environmental effects are also considered where appropriate. The basic principle and main strength of the method, measuring the environmental scarcity with the help of actual pollutants (and resources) flows and maximum allowed (so-called critical) flows, remained untouched. Hence, it is still a distance to target rather than a damage oriented impact assessment method. Nevertheless, the representation of the formula is slightly changed to comply with ISO requirements, but also to allow for a more flexible and powerful interpretation of the terms. The possibilities of the revised formula are presented on the example of the new eco-factor for freshwater resources. The major changes in the impact assessment results are highlighted using examples from the agricultural and industrial sector.

THE ECOLOGICAL SCARCITY METHOD

The Swiss ecological scarcity method is based on the distance to target principle. A **critical flow** is deduced for every substance where legislative guidelines or political goals exist. The **current flow** corresponds to the actual situation. The calculation of the eco-factor is determined by setting the current flow into relation with the critical flow.

Simplicity and transparency of the eco-factor calculation on one hand, and direct derivation from political targets on the other are this method's strength. The use of political targets is the main difference to damage oriented approaches such as the Lime method or the eco-indicator 99. As a consequence, ecological scarcity eco-factors can only be determined for substances with an applicable political target.

There is a main advantage for companies to use the ecological scarcity method. It measures the ecological performance of a company (or its products) with reference to the political agenda of the country or region. In the case of a company this information can be more valuable and relevant than a damage oriented assessment.

The ecological scarcity method is quite popular among Swiss companies. Furthermore, several nations, for example Japan (JEPIX, [1]), have adopted the methodology and are calculating own eco-factors based on their national environmental situation and legislation.

ECOLOGICAL SCARCITY FORMULA

Former and Revised Formula Representation

The formula representation (1) that was used in the former two editions of the Swiss ecological scarcity method [2, 3] is slightly changed (see next page). It allows for a more powerful interpretation. However, from a mathematical point of view the new representation (2) is only a conversion, leading to identical eco-factors as the previous one.

Characterisation

The characterisation term improves the transparency of applying such factors. Characterisation was implicitly used in the previous versions (e.g. global warming potential) but is only now made explicit. The explicitly separated but optional characterisation term is in line with the impact assessment procedure according to the ISO standards.

$$\text{eco-factor} = \frac{1EP}{F_k} \cdot \frac{F}{F_k} \cdot c \qquad (1)$$

$$= 1EP \cdot \underbrace{K}_{\substack{\text{Characterisation} \\ \text{(optional)}}} \cdot \underbrace{\frac{1}{F}}_{\text{Normalisation}} \cdot \underbrace{\left(\frac{F}{F_k}\right)^2}_{\text{Weighting}} \cdot \underbrace{c}_{\substack{\text{Constant} \\ \text{(1e12 UBP/a)}}} \qquad (2)$$

EP : eco - point (the unit)

F : current flow

F_k : critical flow

Normalisation and Weighting

Formerly, the formula contained two weighting terms (see (1)). First, the emission is weighted with regard to the critical flow (how important is an emission in relation to the critical flow?). The second term weights according to the relation between the current flow and the critical flow (how important is the current flow in relation to the critical flow?). Thus normalisation was done with the critical flow and not the current flow as suggested by the ISO standard 14042. Changing normalisation to current flows, the weighting gets actually a squared function.

Furthermore, the weighting factor can be determined independent of the normalisation. This allows for example to determine a weight specific for a local situation (e.g. pollution level of a lake or the water pressure in different countries). The normalisation based on the current flow of the whole country makes eco-factor deduced from a local situation compatible with eco-factors deduced for the whole country. This extension is called "regionalisation". A similar procedure can be applied to define temporally differentiated eco-factors.

NEW ECO-FACTORS

Several new eco-factors are introduced in the ecological scarcity method 2006 such as factors for dioxin and diesel soot emissions into air, emission of endocrine disruptors or radioactive emissions into the ocean. A major progress, however, are the newly introduced assessments of land use and fresh water resources (based on work by Köllner [4] and OECD [5] respectively). While the land use assessment is based on a biodiversity approach very similar to the one already introduced by the eco-indicator 99, the assessment of fresh water resources follows a completely new approach. Furthermore, the assessment of freshwater resources makes use of regionalisation, which became only operationable with the revised formula.

Freshwater Resources – a Regionalised eco-factor

Freshwater is a scarce resource in some regions, while in others it is not. A sound impact assessment method has, therefore, to take these regional differences into account. As a consequence, different weights need to be attributed to water consumption depending on the water scarcity at the place of consumption. Only with the revised formula has it become possible to determine weights separate from normalisation, which is a crucial feature to realise the regionalisation of the weighting.

The OECD [5] measures the pressure on the freshwater resources (i.e. the scarcity) by setting the consumption (drinking water, irrigation, industrial use) in relation to the available renewable water resources. A consumption of a share greater than 40% of the renewable resources is seen as a high pressure while 20% is regarded as medium. It is assumed that a medium pressure is the limit for a sustainable and therefore acceptable pressure (= critical flow, see equations (3) and (4)). From these indications the country or region specific weighting terms can be calculated:

$$\text{Weight (Region A)} = \left(\frac{\text{current flow in Region A}}{\text{critical flow for Region A}}\right)^2 \qquad (3)$$

$$= \left(\frac{\text{water consumption (Region A)}}{\text{renew. water resource (Reg. A)} \cdot 20\%}\right)^2 \qquad (4)$$

The normalisation scales the weighting factors to a country (i.e. Switzerland in our case) for which the resulting eco-factors are valid.

Application of the Regionalised Freshwater Resources eco-factor

Switzerland is a country with a rather low water pressure. Only 5% of the available renewable resources are used. However, Switzerland depends to a good share on imports of fruits and vegetables from countries with a medium to high water pressures (e.g. Spain and Italy, 32% and 23% respectively [6]). Valuating the agricultural water use in the producing countries with the Swiss eco-factor does seriously underestimate the impact from water consumption. Using the proposed regionalised weighting factors avoids this bias; each water consumption would be valuated according to its regional scarcity situation.

Challenges of Applying Regionalised eco-factors

Commercially available LCI databases do not yet differentiate water consumption according to a local water pressure, but only consider the different sources of water such as river, lake, ground-water and ocean. Since it is obvious that a differentiation on a country level is not realistic for a general purpose database (there are about 200 countries in the world), it is proposed to introduce a classification system with a few water pressure levels encompassing the whole range of scarcity. Each level will then be attributed an individual weighting factor (Table 1).

In the previously mentioned example Switzerland (water pressure category: low) imports food products from Spain and Italy with a higher water pressure (category:

medium). Using a regionalised weighting factor results in a factor 36 times higher than without regionalisation. This leads to an increase of the impact from freshwater resources in the same order. Depending on the importance of water resources in the impact assessment this can greatly influence the outcome.

Table 1: Proposed water pressure ranges and resulting weighting factor assuming a critical load of 20%.

	water pressure range	value used for calculation (current load)	weighting factor
low	<0.1	0.05	0.0625
moderate	0.1 to <0.2	0.15	0.563
medium	0.2 to <0.4	0.3	2.25
high	0.4 to <0.6	0.5	6.25
very high	0.6 to <1.0	0.8	16.0
extreme	≥1	1.5	56.3

IMPACT ASSESSMENT RESULTS

Agricultural Products

The assessment shows results for the two vegetables asparagus and tomato produced at a farm (LCI data from Jungbluth [7]). In order to demonstrate the importance of freshwater resources, each vegetable is assessed 1) without irrigation, 2) with irrigation taking place in Switzerland (low weighting-factor for freshwater) and 3) with irrigation taking place in Spain (medium weighting-factor).

As can be seen in Fig. 1 freshwater is of little importance when the asparagus and tomatoes are produced and irrigated in Switzerland (1.6% and 0.13% of the total environmental impact). However, if the asparagus are produced in Spain the freshwater resources contribute 40% to the total impact (5% in the case of tomatoes).

In this example, the assessment of the water use is based on a national average water scarcity in Spain. Differentiating further between individual provinces in Spain (i.e., consider the elevated water pressure of Andalusia), the consumption of freshwater resources would become even more relevant.

These results clearly demonstrate that it can be sensible to use eco-factors that consider the regional or local situation.

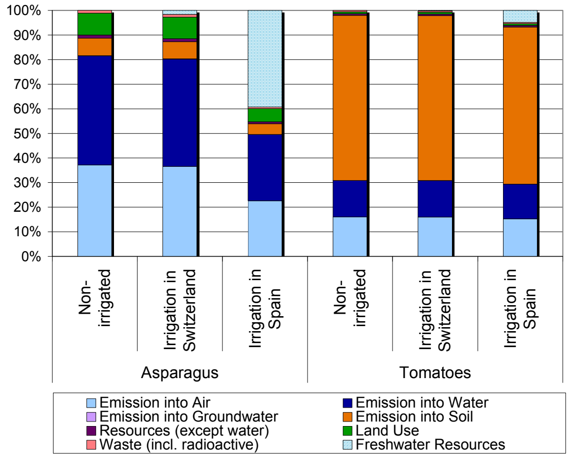

Fig. 1: Assessment of asparagus and tomato with the Swiss ecological scarcity method 06 assuming a low (Swiss) and a medium (Spain) eco-factor for freshwater consumption.

Industrial Goods

The same variation of the eco-factor for the freshwater resources as for the agricultural products is applied on industrial goods (LCI data from the ecoinvent database v1.2 [8]). In contrast to the water dependent agriculture the industrial goods show almost no difference (Fig. 2).

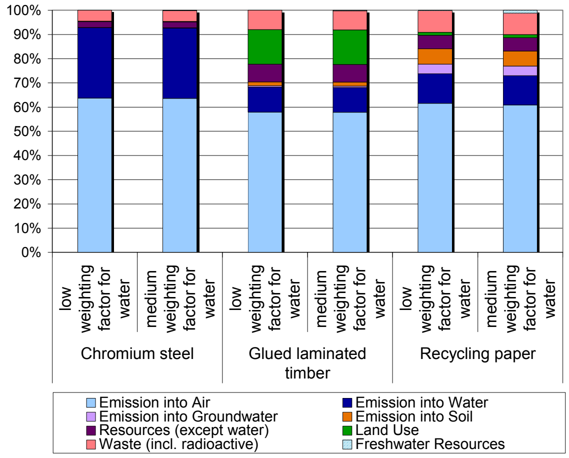

Fig. 2: Assessment of chromium steel, glued laminated timber and recycling paper with the Swiss ecological scarcity method 06 assuming a low and a medium weighting-factor for freshwater consumption.

Hence, the environmental impact from freshwater consumption is often negligible in relation to the other impacts. Recycling paper is the only product shown where a visible share of 1% results with the medium eco-factor for freshwater. Water consumption of industrial processes operated in arid regions might, however, show up in the ecological scarcity results.

CONCLUSIONS

The formula to calculate the ecological scarcity eco-factor has undergone a slight revision. The revised formula provides more possibilities of deducing the eco-factors. The example of the freshwater resource weighting factor, which was deduced for different water scarcity situations, showed on one hand the potential and at the same time the soundness of the approach.

The new structure allows for a use of the ecological scarcity method 2006 (up to the characterisation step) in ISO-compliant studies, a significant improvement with regard to the current situation.

With newly introduced eco-factors the method is capable to include the use of different categories of land, the release of radionuclides to the Sea, the release of endocrine disruptors as well as the consumption of fresh water resources into the impact assessment.

The impact from freshwater resource consumption becomes relevant for products with a high water intensity (e.g. agricultural products with irrigation) and for local situations where the water scarcity is elevated.

REFERENCES

[1] Miyazaki N., Siegenthaler C., Schoenbaum T. and Azuma K., Japan Environmental Policy Priorities Index (JEPIX) - Calculation of Ecofactors for Japan: Method for Environmental Accounting based on the EcoScarcity Principle, International Christian University Social Science Research Institute, Monograph Series No. 7, Tokyo, 2004

[2] Ahbe S., Braunschweig A. and Müller-Wenk R., Methodik für Ökobilanzen auf der Basis ökologischer Optimierung, Bundesamt für Umwelt, Wald und Landschaft (BUWAL) No. 133, Bern, 1990

[3] Brand G., Scheidegger A., Schwank O. and Braunschweig A., Bewertung in Ökobilanzen mit der Methode der ökologischen Knappheit - Ökofaktoren 1997, Bundesamt für Umwelt, Wald und Landschaft (BUWAL) No. Schriftenreihe Umwelt 297, Bern, 1998

[4] Köllner T., Land Use in Product Life Cycles and its Consequences for Ecosystem Quality, in Difo-Druck GmbH, Bamberg. 2001, Universität St. Gallen, Hochschule für Wirtschafts-, Rechts- und Sozialwissenschaften (HSG), St. Gallen, pp. 237

[5] OECD, Key environmental indicators, OECD Environment Directorate, Paris, http://www.oecd.org/dataoecd/32/20/31558547.pdf, 16.06.2005 2004

[6] FAO, Aquastat: FAO's Information System on Water and Agriculture, Database, http://www.fao.org/ag/agl/aglw/aquastat/dbase/index.stm, Withdrawn Date: Date

[7] Jungbluth N., Umweltfolgen des Nahrungsmittelkonsums: Beurteilung von Produktmerkmalen auf Grundlage einer modularen Ökobilanz. 2000, Eidgenössische Technische Hochschule Zürich, Umweltnatur- und Umweltsozialwissenschaften, dissertation.de, Berlin, D, pp. 317

[8] ecoinvent Centre, ecoinvent data v1.2 with corrections, Final reports ecoinvent 2000 No. 1-16, Swiss Centre for Life Cycle Inventories, CD-ROM No. ISBN 3-905594-38-2, Dübendorf, CH, www.ecoinvent.org, 2006