THE INTEGRATION OF ECONOMIC AND SOCIAL ASPECTS IN LIFE CYCLE IMPACT ASSESSMENT

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Common roots of CBA and LCA

Cost-benefit analysis (CBA) and life cycle assessment (LCA) share the objective to provide holistic, ex-ante assessments of human activities, and both techniques have developed from engineering practice. In spite of this common objective and the common roots, CBA and LCA have developed in relative isolation. This has resulted in a situation where much can be gained from an integration of the strong features of each technique. Such integration is now being prompted by the more widespread use of both CBA and LCA on the global arena, where also the issues of social responsibility are now in focus. Thus, it is time to sketch a common frame of understanding of environmental externalities. Such a common frame is provided by the conceptual structure of life cycle impact assessment (LCIA) developed by within the SETAC/UNEP Life Cycle Initiative (Jolliet et al. 2004).

The SETAC/UNEP LCIA framework

The advantage of the SETAC/UNEP LCIA framework is that it provides a comprehensive classification for environmental externalities. It subdivides the environment in three compartments ("Humans", "Non-human, biotic" and "Non-human, a-biotic"), thus together covering the entire world. Part of these environmental compartments may then be designated as "safeguard subjects", i.e. the things that we value and wish to safeguard within each environmental compartment. Safeguard subjects can be of both intrinsic and instrumental value (the latter called functional in Jolliet et al. 2004) so we obtain in total 6 overall "areas of protection" (see Table 1).

Table 1. Areas of protection in the SETAC/UNEP LCIA framework (slightly modified from Jolliet et al. 2003a)

Objects considered: Endpoint value:	**Humans**	**Biotic environment (natural and man-made)**	**Abiotic environment (natural and man-made)**
Intrinsic	Human health (and well-being)	Biodiversity (and well-being of animals in human care)	Natural and cultural heritage
Instrumental	Human productivity	Ecosystem productivity	Natural resources and man-made capital

Integrating social aspects in life cycle assessment

The concept of impact chains, linking biophysical and economic inventory results via midpoint impact indicators to final damage indicators, is well

described in the LCA and CBA literature. In social impact assessment, the concept has only recently been introduced (van Schooten et al. 2003).

Under the general heading of human life and well-being in Table 1, the following damage categories can be identified, as the different aspects of human life that has intrinsic value: Life and longevity, Health, Autonomy, Safety, security and tranquillity, Equal opportunities, and Participation and influence.

Changes in the expected length of life are measured by the damage indicator Years of Life Lost (YLL), as in the Global Burden of Disease study (Murray & Lopez 1996). Non-fatal impacts on human health are measured in terms of the type of disability (disease or injury) and the duration of the condition. The unit of the damage indicator is therefore disability-years. To each form of disability, a severity may be assigned on a scale between 0 and 1, where 0 is equal to death. The resulting damage indicator is called healthy Years Lost due to Disability (YLD), and can be aggregated to the years of life lost (YLL), using the common unit of DALY (Disability Adjusted Life Years).

In analogy to the health impacts, the other impacts on well-being (autonomy, safety, security and tranquillity, equal opportunities and participation and influence) require measures of incidence (number of persons affected) and duration of the impacts. As for health impacts, these other well-being impacts may be assigned a severity ("well-being weight") on a scale between 0 and 1, where 0 is equal to death. The resulting damage indicator is Years of Well-being Loss (YWL) and is comparable to Years Lost due to Disability (YLD) and years of life lost (YLL), using the common unit of QALY (Quality Adjusted Life Years), where a well-being impact with a severity weight of 0.5 and a duration of 1 year for 1 person will be recorded as a damage of 0.5 QALY, thus equal to 0.5 YLL, i.e. a reduction of life expectancy of 0.5 years for 1 person. Defined in this way, QALYs are conceptually equivalent to the "Happy Life Expectancy" suggested by Kunst et al. (1990) and Veenhoven (1996).

A first attempt at measuring the global burden of well-being in this way can be found in Table 2, with more specification in Tables 3 and 4.

Table 2. A first estimate of the global burden of well-being impacts

Impact	Total damage [E+6 QALY]	% of full wellbeing
Value of full well-being before impacts	6230	100%
Mortality[1]	-1700	-27%
Non-lethal health impacts[1]	-960	-15%
Autonomy infringements[2]	-930	-15%
Anxiety[3]	-300	-5%
Unequal opportunities[4]	-160	-3%
Participation restrictions[5]	-380	-6%
Current level of well-being	1800	29%

[1] WHO World Health Report 2002. Value without age weighting and discounting.
[2] See Table 3.

[3] See Table 4.
[4] 0.1 QALY per person for the most disadvantaged ¼ of the global population (1.6 E+9 people).
[5] Violation of political rights: 0.1 QALY per person affected; Violation of union rights: 0.05 QALY per person affected; prevalence 2.4 E+9 and 2.7 E+9 people, respectively (based on Piano & Puddington 2004 and Kucera 2004).

Table 3. A first estimate of the global burden of autonomy infringements. Details on data sources and calculations will appear in Weidema (2005).

Infringement	**Incidences, E+6 capita per year**	**Total short term damage, E+6 QALY**	**Total long term damage, E+6 QALY**	**Total damage, E+6 QALY**
Bonded labour	4	8	7	15
Child labour	36	72	162	234
Trafficking	3.7	3	14	17
Incarceration	9	7	0	7
Excessive work	1000	200	0	200
Torture	0.1	3	14	17
Genital mutilations, female	2	1	14	15
Genital mutilations, male	13	4	0	4
Interpersonal or communal violence	26	5	0	5
	10% of which	1	11	11
Crime victim compensation	4	-0.4		-0.4
No access to contraceptives	200 (women)	20		20
Unwanted pregnancies	60	12	90	102
Refugees or internally displaced	37	11	0	11
Warehoused refugees (> 5 years)	1.6	12	35	47
Infringement of freedom of expression	2400	240		240
Sum		*596*	*334*	*929*

Table 4. A first estimate of the global burden of non-clinical anxiety. Details on data sources and calculations will appear in Weidema (2005).

Impact	Capita affected annually, E+6	Total damage, E+6 QALY
Inadequate access to health care	1600	140
Inadequate access to pensions or social security	680	61
Threats of violence or other contact crimes	130	12
Burglary or attempted burglary	220	20
Threatening or traumatic traffic situations	140	13
Stressful working conditions	600	54
Sum		*300*

Integrating economic aspects in life cycle assessment

The three instrumental endpoints in Table 1 all deal with aspects of economics: human productivity, biotic productivity and natural and man-made capital, which may therefore be measured in monetary units.

As an example of this, Table 5 provides a first estimate of the global burden of impacts on human productivity, expressed in terms of the productivity gap between the current Gross Economic Product (the sum of the Gross Domestic Production and the Gross Household Production, having a value of roughly ½ of the GDP) and an ideal production without the listed impacts.

Table 5. First estimate of the global impacts on human productivity

	$USD_{2000PPS}$/capita
Unemployment and underemployment[1]	960
Health and other work-disabling impacts[2]	5800
Effect of trade barriers[3]	5200
Missing education[4]	9700
Lacking physical infrastructure[5]	4500
Lacking social infrastructure[6]	5900
Sum of individual impacts	*32000*
Synergy effect[7]	34000
Sum with synergy effect	*66000*

[1] Current global labour force participation 0.446 versus an ideal 0.5. Current global unemployment 9.6% versus an ideal 3%. Only 30% of the impact has been included, due to the offsetting impact on household production.
[2] Current health gap 24% + 1% to account for productivity impact of autonomy infringements.
[3] Estimated 5 times the value for trade barriers on goods according to Newfarmer (2001).
[4] 10% increase in GDP per year of additional schooling until 12 years, 6.8% increase in GDP per year of additional schooling between 12 years and 18 years. Current global school expectancy 11.5 years (UNESCO 2005).
[5] Based on Yeaple & Golub (2002), using current USA as an "ideal" reference level.
[6] Residual difference between current global and current USA when above factors have been accounted for.
[7] As the above impacts are multiplicative, there is a considerable synergy effect of combined impacts.

Impact pathways for social and economic inventory indicators

Having listed and quantified the damage categories, the next challenge is to model the social and economic impact pathways from the social and economic inventory results to the damage indicators. Although many relationships are still only scarcely researched, there is a growing body of knowledge that seeks to explain the causal links of social and economic sustainability, and it is therefore my suggestion that such a quantitative modelling – at least at a very rough level – is already possible based on existing research and data.

This extended abstract leaves only room for one such example: The relationship between the inventory indicator "hours of child labour" and the impact indicators "autonomy infringements" (measured in QALY) and "human productivity" (measured in monetary units). Assuming that the inventory indicator includes only serious forms of child labour, which limits the child's ability to follow normal school and other activities necessary for full physical and mental development, it is reasonable to assume a linear relationship between hours of child work and the impact in QALY (1.3 QALY per year of child labour, including the long-term impacts; see Table 3, which translates to 6.5 E-4 QALY per hour of child labour, if a working year is set to 2000 hours). Child labour also affects human productivity negatively, since the lack of education (and possible other abuse) leads to lower productivity of the affected individual. A rough estimate of the size of this impact is that per year of lost education, the victim's production is reduced by 10% of the average wage in the country of incidence; see also Table 5. Since this applies to the rest of the victim's productive life

(estimated at 30 years), this translates to a loss for each hour of child labour of 3 times the average hourly wage of the country, i.e. a significant loss both for the victim and for the society in which he/she lives.

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