

The Areas of Protection Debate: Phase A (pp 2-13)

Phase A relates to the [1st Draft of the Areas of Protection](#) (mostly in December 2000)

A1: David Pennington (5 December 2000)***Helias:***

Thank you for the opportunity to comment on the draft manuscript "Review of Areas of Protection within the Working Group on LCIA". As we had little time in Brussels to discuss this in depth, with the possible exception of the diagram, please find below my comments related to the entire manuscript.

1) It was unclear why car accidents should not be included in LCA, particularly when cases such as impacts on wildlife from accidents were later suggested for inclusion. I feel that this is really up to the practitioner/decision maker and is a question of scope of the LCA. You note on page 2 that wildlife is part of the natural environment and therefore justify its inclusion. Based on this, and the belief that humans are still part of the animal kingdom even if they are often separated out as a particular safeguard subject, I do not see why accidents involving humans are not similarly taken into account - if the scope demands it.

2) Life support functions are part of other impact categories that already exist, I think in all cases (especially if man-made environments are included to account for buildings, crops, ...). Associated measures can therefore be considered as important midpoint measures, with great uncertainties as to what happens after the midpoint (climate change and associated endpoints being a good example). In Brighton, there was good agreement that available LCIA approaches should include both midpoint and endpoint measures, partly for this reason. These midpoint measures are therefore linked to the life support systems integrity. This can be noted but may not constitute a separate safeguard group, unless the decision maker decides that this is part of their goal.

3) In the overview (section 4), under Natural Environment you include biodiversity but not other measures of the welfare of species or ecosystems. Similarly the other categories do not include comprehensive lists. Accidents to humans associated with the life cycle of a product, e.g. the increased use of transport, could be and maybe should be included under human health.

4) As mentioned in Brussels, I have conceptual problems with the diagram. Firstly, I do not believe that society (and societal values) should be at the centre of the diagram - for many reasons. I believe that the environment and the sub-category of life support systems are at the centre, as everything is dependent on these. This supports many safeguard subjects, such as the availability of resources, human health, ecosystem health, the construction and maintenance of societies, ... (Interesting to note the book in SETAC news that provides illustrations of societal dependence on the environment and cases where this has gone very wrong, due to over exploitation, etc.). Note also, again, that many links are also missing between the life support systems and other safe-guard areas. Putting the environment and the subcategory of life support systems at the centre will help include these links, among other advantages.

Hope these comments help and look forward to the next proposals, possibly separating the discussion of what is included in manmade environments, etc., from that of the importance of midpoint measures and life support systems.

David Pennington

A2: Erwin Lindeijer (6 December 2000) Comments to A1

Thanks for your comments, David. I could not be in Brussels, but from previous meetings I reckon there was hardly any time to discuss thoroughly the paper on Areas of Protection. I thus also do not know whether a conclusion was drawn. But here I give some reactions to your comments.

1) It was unclear why car accidents should not be included in LCA, particularly when cases such as impacts on wildlife from accidents were later suggested for inclusion. I feel that this is really upto the practitioner/decision maker and is a question of scope of the LCA. You note on page 2 that wildlife is part of the natural environment and therefore justify its inclusion. Based on this, and the belief that humans are still part of the animal kingdom even if they are often separated out as a particular safeguard subject, I do not see why accidents involving humans are not similarly taken into account - if the scope demands it.

Erwin:

I guess the argument used to exclude car accidents with humans is that these impacts do not go from the technosphere (intervention) via the environment to humans. Akin examples are mine field victims and passive smoking victims. Probably workers health impacts would fall in this category too. If you would say that these cause-effect chains do go via the environment, that would for me imply a very broad definition of the environment. Not necessarily problematic, but the implications of setting such broad system boundaries requires a consistent inclusion of all these and similar examples. For instance, including only car accidents, because a hidden goal of the study would be to show how irrelevant environmental impacts in the narrow sense are, or to focus on car accidents as an environmental impact while ignoring smoking impacts and workers impacts as such will obviously give skewed results of your LCA.

There are various layers of system boundaries which imply including more or less impact categories in an LCA. I suggest to define these system boundaries clearly, and to be consistent in using one or the other. The amount of work to include all these broad-sense environment issues consistently may become prohibitive, I fear. By the way, drought sufferings should for similar reasons be included only in a narrow system boundary setting when they are modelled to be caused by an interference of human interventions with the climate.

David:

2) Life support functions are part of other impact categories that already exist. Associated measures can therefore be considered as important midpoint measures, with great uncertainties as to what happens after the midpoint (climate change and associated endpoints being a good example). In Brighton, there was good agreement that available LCIA approaches should include both midpoint and endpoint measures, partly for this reason. These midpoint measures are therefore linked to the life support systems integrity. This can be noted but may not constitute a separate safeguard group, unless the decision maker decides that this is part of their goal.

Erwin:

I do not agree with your formulation that LSF are part of other IC. They are not an impact category in my terminology, at least. Impacts on different LSF may be expressed as different IC's. And although I do not think that all these IC exist at present (soil quality, Albedo effect, water flows etc.), more important is that our message is that taking care of these environmental LSF in itself is a safeguard subject. Indeed this overlaps with other SaSus, as midpoint SaSus. In interpretation this requires careful consideration, and in top-down approaches this LSS will probably be ignored as a separate SaSu. However, both the inherent uncertainties in environmental modelling and delayed possible impacts lead to safeguarding politics on the level of this SaSu, as the Dutch government does. For decision

making, separate assessment of the LSS is required. Excluding this SaSu on beforehand is thus not obvious and more due to the history of LCA.

David:

3) In the overview (section 4), under Natural Environment you include biodiversity but not other measures of the welfare of species or ecosystems. Similarly the other categories do not include comprehensive lists. Accidents to humans associated with the life cycle of a product, e.g. the increased use of transport, could be and maybe should be included under human health.

Erwin:

I am sincerely interested to see what examples you would give for other measures on species and ecosystem welfare.

4) As mentioned in Brussels, I have conceptual problems with the diagram. Firstly, I do not believe that society (and societal values) should be at the centre of the diagram - for many reasons. I believe that the environment and the sub-category of life support systems are at the centre, as everything is dependent on these. This supports many safeguard subjects, such as the availability of resources, human health, ecosystem health, the construction and maintenance of societies, ... (Interesting to note the book in SETAC news that provides illustrations of societal dependence on the environment and cases where this has gone very wrong, due to over exploitation, etc.). Note also, again, that many links are also missing between the life support systems and other safe-guard areas. Putting the environment and the subcategory of life support systems at the centre will help include these links, among other advantages.

Erwin:

Making the environment as the background on which the society is placed was meant to illustrate societies dependence on it. However, Helias and I will discuss this.

David:

Hope these comments help and look forward to the next proposals, possibly separating the discussion of what is included in manmade environments, etc., from that of the importance of midpoint measures and life support systems.

Erwin - I agree fully with your last proposal.

Erwin Lindeijer

A3: Bo Weidema (7 December 2000)

Dear all,

I strongly agree with David that the exclusion of e.g. car accidents, involuntary smoking, animal welfare etc. in LCA is not very well-founded. The argument of what is an environmental effect and what is not is not very convincing, and if taken at face value it is in conflict with the whole idea of the nice graph presently being discussed. Fundamentally, the world is divided in two parts (as in the figure), the (totality of the) product systems that we study, and the environment. The environment is per definition (see also ISO) everything which is not included in the system that we study. This implies that every effect must either be inside the system or part of the environment. If we exclude car accidents as an environmental effect, we must include it inside our system (as the processes involved at hospitals, car repair shops etc.). Ignoring an effect can only be justified if it is truly negligible. Thus, the discussion should focus on what effects we prefer to model within our systems (i.e. within society) and what effects we prefer to model as external, i.e. environmental effects. One criteria for this division could be (as suggested in my poster at Brighton) the degree of knowledge/certainty of the effect chain. Other criteria may possibly be derived from the consideration re. safeguard subjects. **Best wishes, Bo Weidema**

A4: David Pennington (7 December 2000)

A few further comments in reply and then I leave you with these thoughts for a while, including the call for another USEPA/SETAC/UNEP workshop/working group on this crucial LCIA "taxonomy" question:

1) For indicators of ecosystem welfare other than biodiversity, I suggest looking at the vast eco-indicator literature (not to be confused with eco.ind.99!). We are also doing this. I note that PAF is not a measure of biodiversity, for example, but measure of the number of species affected.

2) Just to stress again, an outcome of the Brighton workshop was to stress that both midpoint and endpoint measures should be presented (the exact wording can be found in the workshop summary paper, published in the Int. J. of LCA Vol. 5, No 6 319-326 (2000)). This outcome was partly due to uncertainty issues and partly due to the importance, in their own right, of these midpoints (or LSSs in some cases such as global warming), among other reasons. This outcome may be in support of your arguments. (Sorry if I previously mixed terminology of safeguard subjects and impact categories!)

3) We are interested in the impacts associated with supplying a (product) service, taking into account all stages of its life cycle. These are not necessarily only impacts on or via the natural environment, in the broad sense. Most LCAs however adopt this scope. Hence, for example, significant impacts of increased vehicle transport on wildlife and humans via accidents are commonly ignored. However, note, impacts on wildlife and human health are impacts on the natural environment and should not be ignored give such a definition. As you state, we may be ignoring the most important affects these two safeguard subjects in some LCAs - if these impacts are more significant than those of the associated transport emissions. In many cases we are limiting the scope of the impacts addressed and, hence, distorting the true picture of the impacts of one LCA compared to another, for practical reasons and/or reflecting a defined scope. I feel it is dangerous, however, to just say that impacts such as accidents to the natural environment should not be included in the context of the LCA framework, although many LCAs will continue to focus on only certain impact categories defined in their scope. I note that accidents are usually much easier to account for, and more certain, using available statistics than impacts associated with emissions. It is not therefore clear why this increases the challenge to LCA practitioners - maybe it is better to ignore smaller impacts of vehicle emissions than to ignore the more easily addressed and important impacts of accidents on human health, for example (?). As for drought, smoking, etc., are these related directly to the product-service? - this may be a very interesting research/ethical question (exploitation of the developing world, etc.).

Concerning fears that we are increasing the scope of LCA beyond manageable limits, should we therefore exclude noise impacts on humans and wildlife, etc., in the general framework? I cannot see the difference, except in terms of importance, between noise impacts and accidents. I note that noise impacts are already accepted by many as a potential "candidate impact category" for the LCIA framework.

4) Thanks for reconsidering that human society is at the centre of everything and that the environment is only in the background (in the diagram!). Anyway, hope this all helps. It was not possible in Brussels to have an in-depth discussion of this topic, with the exclusion of a chance to raise a few issues related to the category interaction diagram. I have heard a strong call from many for a "taxonomy" or structure to how impact categories are included in an LCIA and how they are selected. Some critics have very strongly referred to LCIA as ad-hoc and, hence, non-scientific. Your efforts could be a step in the direction of addressing such criticisms. I would suggest that this is a perfect topic for a future LCIA workshop such as the series by Jane Bare et al. (US EPA, UNEP, CML) - to develop structured framework for impacts associated with a product-service (with subsections to identify the overall framework; on impacts to the natural environment via vehicular accidents and noise; on impacts indirectly via

exploitation of developing nations; on impacts indirectly via work injuries, smoking, drinking, stress, ...).

Hope this all helps with the thinking process and look forward to seeing future draft paper, as well as the idea of attending an associated workshop to address this topic.

David

P.S. I also think that this should be the focus of a SETAC/UNEP working group and that issues related to developing countries such as the indirect impacts of services via famine and droughts may be of great/direct interest to UNEP.

A5: David Pennington (8 December 2000)

Based on the ISO definition and some insights from Olivier, I now follow better why the environment is considered a "background" in LCA and why it is therefore represented in this way in the current diagram. My perspective continues to be that the environment is what we are trying to ultimately protect, the ultimate safeguard subject. Humans are part of the living environment, as part of the animal kingdom. This causes some complication if the environment is considered to be the background, as humans are therefore also part of the background. Perhaps this is not what was meant but this is a source of confusion and a strange definition, I feel, for the environment that supports us and that should be very much the focus. It appears that there is a different perspective in life cycle assessment when considering inputs and outputs across a life cycle boundary - the environment then becomes the surroundings to the modeled system boundary; until we start to model parts of the environment, splitting it across this artificial boundary - hence our problem, what environmental attributes are inside and what are outside. Although I do not answer this question, I therefore question the concept/ISO definition that the "environment" can be defined simply as the "background" - this may be one of the implications from looking at just the technosphere in LCA and also one definition in the dictionary, but it is not so applicable when we address LCIA.

For LCIA, I feel that the environment is the starting point for defining what we are trying to protect. Hence, the environment is the centre or the top of the diagram (or hierarchy). The environment then consists of many attributes, including the living environment. The living environment includes the animal kingdom, among others and for which a taxonomy exists in most biology texts. We have then selected some species such as humans as key safeguard subjects.

Overlapping or inputting into this classification structure, we then have insults to the environment. These insults can affect many elements at different levels. For example, global warming may cause changes in oceanic cycles that are essential to support the entire living environment (life support systems class?), with indirect consequences down the hierarchy on human health, etc. Other impacts may be more localised at lower levels of the environmental hierarchy, such as toxicological affects directly influencing human health. From this starting point of an environmental hierarchy, we can then begin to see where and what anthropogenic changes will influence - their significance is partly dependent on their height in the hierarchy. Global warming (or climate change!) can be seen to influence the hierarchy near the top, with a lot of potentially serious consequences but also with huge uncertainty.

Toxicological impacts may only affect certain species in the living environment further down the hierarchy.

Just some more thoughts to add to the overall discussion. This idea maybe starts to provide an idea for the structure of the environment and the associated safeguard attributes. I am not sure that the insults on these attributes can be so easily classified, as they are almost random attacks on the hierarchy at different levels.

Again, I look forward to reading the future position paper on coming up with an overall structure for safeguard subjects and impact categories, as well as the possibility of attending an associated workshop with experts from the many associated scientific domains.

David

A6: Patrick Hofstetter (11 December 2000)

Dear David (and Bo, Erwin, Helias, silent readers):

Congratulations to Helias and Erwin to produce this discussion paper and to David to initiate this e-mail discussion. David, you asked me for a reaction on the issues. I guess you do so because I was (probably next to Ruedi Mueller-Wenk) the only one who questioned the WIA-2 proposal in Udo de Haes et al. 1999 (see Hofstetter 1999). I include at the end of my reaction a number of references that dealt with these questions. Those are to a large share references in the literature that deals with damage-oriented approaches because those approaches force us to be explicit on some of the addressed questions. Instead of trying to repeat myself or repeat findings of others I will react here on three major points:

1. The distinction between intrinsic AoP and operational AoP
2. Rational for including pathways
3. My reaction on the LSS proposal

ad 1):

Part of the discussion of the proposal (and my reactions in Hofstetter 1999 on Udo de Haes et al. 1999) is sidetracked by two very different issues:

The identification of AoP versus the question whether all types and causes of (adverse) changes to these AoP shall be included in LCA. The AoP discussion makes in my view only sense if they are understood in the way we use the term 'safeguard subject (SaSu)'. SaSu are used to specify what is considered to have intrinsic values within the fuzzy thing 'environment' and allow justifying why only changes to these SaSu need to be assessed.

As Beltrani (1997) points out and Hofstetter 1996 illustrates, (a) whether we assign intrinsic values to a subject or not depends on our world-view and (b) for pragmatic/feasibility reasons we may choose assessing changes to a SaSu that has no intrinsic values but stands in a close relation to a SaSu with intrinsic value but without quantified cause-effect relationship. Because of (a) it would be surprising if we agree on the SaSu and because the question of feasibility is again a matter of world views, we may also disagree on that (Examples: The Risk Trade-Off Analysis of the Harvard Center of Risk Analysis (see articles by Hammitt et al. and Gray et al. In the 1999 and 2000 issues of Risk Analysis) targets on human health impacts assuming that all relevant indirect impacts mediated by the environment can be modeled to this endpoint. Ruedi Mueller-Wenk suggested in an earlier approach to directly assess the consequences of resource depletion on human health.). With respect to the proposal this means that Helias and Erwin need to be explicit on which AoP have intrinsic values and which are added because they do not believe that quantitative modeling is possible to a upper level. Once this is explicitly made, it is important to be precise on what is excluded in the "Operational AoP" because they are included directly in the "Intrinsic AoP". Personally, I think that we should not assume that we will find agreement on such a structure. However, there may well be a subgroup of researchers that can come up with a consistent proposal they agree on.

ad 2):

David asks why accidents have been excluded, Bo agrees with David's concerns and Erwin is of course right in warning that we need to limit LCA to stay feasible. I tend to agree with David and argue that once the AoP are agreed on no impact pathways can be excluded per se. To do so we need to know (a) the specific decision at hand and (b) the other decision support systems used complimentary to LCA. (a) is important because it will help us to decide what can be assumed to stay constant and what will change when the decision is made (when does ceteris paribus apply?). (b) allows us to exclude pathways because they are assessed in

other tools. The main effects of traffic accidents are human fatalities and injuries (but also vehicle repair/replacement, running emergency services and hospitals, infrastructure that should prevent accidents?). Fatalities and injuries are adverse changes to human health and therefore in principal to be accounted for. If I assess life cycle environmental impacts of different modes of transport for a weekend city escape (train, car, plane), then the potential traveler may not want to include her personal accidental risk in the human health impact caused by the different modes of transport but may want to get this information on personal risk as a separate piece of information. Although this rational supports the exclusion of this direct accidental impacts there are other traffic accidents that would be included because of indirect transport requirements and the induced in/decrease in accidents due to the change in number of vehicles using the infrastructure. However, if I assess products that require different amounts or modes of transport then the accidental risk of each individual involved may be part of the analysis. I use "may" because one can also ask about the environmental impacts of products to non-compensated individuals. Many economists would argue that truck drivers but also factory workers in high-risk occupations are already compensated for their increased risk. Therefore, this would not be considered as an externality.

I hope that these examples illustrate that we need to know more to decide on the in/exclusion of accidents - and that worker's accidents, injuries or illnesses are different from non-compensated individuals and should therefore not simply be added to effects of non-compensated individuals. While the discussion on hand of accidents or occupational health is comparably easy it gets really messy when damages to man-made environment need to be assessed. The reason is that we do not only need to decide whether this information will already be provided by complimentary tools and whether they are externalities or not but also whether they are actually pathways that will affect the other AoP with intrinsic value or not.

ad 3):

I like the LSS idea. It is indeed likely that not only the operational pathways to the AoP with intrinsic values (human health, natural environment) but also the ones to the AoP with operational value (natural resources, man-made environment) represent only a small share of the actually existing pathways. Decision makers with a more holistic understanding of knowledge, tendency to risk-aversion and preventive managing styles may like to also consider information that may be used as proxies for such pathways that cannot be modeled. For me, the proposal to add a LSS attempts therefore the same as "my" proxy for unknown damages (Hofstetter 1998). Typically, such proxies consider information early in the cause effect chain like fate and exposure characteristics. The challenge is not only to have a convincing rational for the selection of these proxy characteristics but even more that there may be no rational to combine different properties. If the LSS indeed consists out of all mentioned indicators then we may not find a convincing way to combine those to one proxy indicator. This means that we do not know the "exchange rates" between these indicators and can only support decisions in cases of dominated solutions. If the LSS is added, I suggest limiting its scope to consider one inherent property only.

I hope that some of my comments are a micro-step into understanding better how our framing for LCIA might look like. I am glad to see that the WIA-2 shows finally the openness we need to address these essential questions. I also think that David's proposal to make this discussion a priority for an international discussion is a good one. If we do so, we may either need to make sure that a couple of colleagues do a lot of preparation work to present more consistent proposals or that the event will be a true workshop.

Thanks to all those who are still with me

Patrick

Literature

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A7: Bengt Steen (12 December 2000)

Dear all,

A few comments from one of the so far silent readers, who has followed an interesting discussion where many relevant questions have been brought up. I agree in particular with Patricks contribution. I would like to elaborate on some of the points there and add some new:

1. Safeguard Subjects or AoP:s are used in Sweden and I think also in other OECD countries in order to describe general and long term goals for the environment. As such they are really expressing societal concerns.
2. I prefer the term 'Safeguard Subject' before AoP. This is because it is easier to name, define and conceptualise a subject than an area. The area is defined by its system borders, which are complicated to describe.
3. I think of Safeguard Subjects or AoP:s as strategic defence lines. Sometimes You chose to separately safeguard something that is a bit early in a cause-effect chain, just because you do not know how it is going to influence you even if it is likely to be covered by another safeguard subject, e.g. as for biodiversity and natural resources.
4. The primary 'function' of Safeguard Subjects or AoP:s is to help to structure our thinking. They can be used as a kind of checklist when we select impact categories and indicators. It is not a big issue if they overlap and we discover the same impact category or category indicator twice. It is a big issue if we miss some essential environmental effect.
5. When selecting indicators at the endpoint level, Safeguard Subjects or AoP:s have a more simple relation to impact indicators than when being at the midpoint or starting level. At endpoint level they may be used as 'superior impact categories'. At midpoint or starting level, there is a need to identify pathways and mechanisms
6. Some of our problems of finding a logical structure are caused by the lack of an identified application. If you want to be able to describe "everything that may be of interest" you will have to live with a certain lack of focus and

order. One such lack of order that make me concerned is that WIA-2 does not seem to organise its selection of indicators according to whether it is in the beginning, mid point or endpoint level. Now we find indicators at all levels mixed. Some are at the intervention level, e.g. land use impacts, noise impacts and car accidents, some are at the midpoint level, e.g. GWP and some are at the endpoint level like human toxicity. This becomes a problem when the results are going to be evaluated, e.g. by weighting. I would suggest organising them in separate groups. To cover car accidents at midpoint level I suggest classifying them as physical impacts.

7. I have some problem with the conceptual model given in the paper by Erwin and Helias. What is it going to be used for? Does it describe information structure, processes or systems? It does not use any of the established model languages, why it needs some explanatory text in the article.

Finally I have some direct comments on the text in the paper by Helias and Erwin. They are attached as comments and suggested editorial changes using the review tool in word.

With best regards,

Bengt Steen

A8: Willie Owens (12 December 2000)

Bengt's remarks - like the concept of the 'safeguard subject' are strategically placed - I concur that these are to set in motion our thinking - here's what we would conceptually like to protect - now, how does one do that? What should follow is 1) the 'rationale' that constructs a list of options, 2) an analysis of how these options work (including what they require of the inventory so that we have a practical idea of what kind of information we will get for what degree of effort) and 3) 'justification' for selecting and using one of these - and by having clear thinking and putting it on paper - we also provide transparency.

And a word of warning - apologize in advance for my usual bluntness - the tendency to continually create new terms and definitions - while fun - also causes a great deal of confusion in the external world and causes doubts to be raised about the value of what the practioners (who seem to appears to be riding a 'merry go round' of terms) have to offer.

Willie

A9: Ruedi Müller-Wenk (14 December 2000)

Dear colleagues,

Please allow me to add some additional thoughts to the original proposal Erwin/Helias and your various reactions to it:

A. Life-Support Functions: Mid-points or additional Areas of Protection AoP ?

In (Udo de Haes et al. 1999, Int. J. LCA 4 (2) 66-74 and (4) 167-174, section 2.2 and fig 4), life-support functions are apparently located at mid-point level. The reasons given by Erwin to change this now are not convincing:

- High uncertainty and long time constants exist also on other cause-damage links, and uncertainty varies with knowledge
- Society's concerns can be heard with respect to many midpoints thus being no argument for creating a new AoP
- Natural Environment is surely more heterogeneous than Human Health, but this does not disappear with the new AoP.

On the other hand, there is a good argument to keep items like climate system at midpoint level: This reminds us that we must continue to improve our knowledge on the damages caused by changed temperatures and rainfalls. Temperature increase as such is not a damage, but the consequences of temperature increase on human life, non-human life and other objects may be damages - and perhaps benefits in certain cases.

In consequence, I SUGGEST to keep Live-Support Functions at midpoint level as before.

B. Natural Resources: Depletion and Competition

If a living or non-living element of nature is limited in supply but valuable as an input to certain civilisation processes, this leads to a long-term (depletion) and an short-term (competition) distribution problem.

In contrary to what Erwin writes, deposit resources cannot only be depleted, but there is ALSO competition for them. If we try to include both in LCA, we come into troubles. Lets consider the LCA-case of exploring and bringing to production 50 new oilfields increasing the yearly global oil production by 30%. This will be a benefit from a competition point of view: the producers bring more oil on the market, the price per barrel will go down, and the consumers can buy and burn more oil. From a depletion point of view, this will be a damage, because the endowment of earth with fossil oil will decrease faster.

But do we really want to include both aspects in a LCA ? Until now, Consumer Wealth is not mentioned under the Areas of Protection. If the object of an LCA study leads to the benefit of decreased competition for oil, this midpoint has no relationship at all to any of the given Areas of Protection. In contrary to the case of climate change where we have still insufficient knowledge but know that AoP Human Health is at stake, the cause-impact line from oil extraction to increase of competition has no continuation AT ALL to the Areas of Protection.

In consequence, I SUGGEST not to include the aspect of increasing/decreasing competition into the cause-impact chains originating from resource extraction. Increase of competition for resources is an important issue - but it will be considered by decision makers as one of the aspects outside of LCA results.

C. What is an Environmental Process?

The notion of Environmental Process is important, because Erwin mentions that - damages to AoP Manmade Environment should only be included in LCA if environmental processes are involved - even damages to other AoP should only be included if environmental processes involved (see victim of car accident!).

It is therefore useful to find a clear answer to the question: What is an environmental process (or mechanism)? Bo has given such an answer, but practitioners might possibly consider it as not very helpful.

If we include not only emission impacts, but also impacts from extraction and from land use, defining an Environmental Process becomes rather tricky. I therefore SUGGEST to start modestly with a positive list (Cases of Environmental Processes) and a negative list (NOT cases of Environmental Processes), and I begin the 2 lists as follows:

Cases of Environmental Processes:

- Transfer of materials/energy emissions from a factory or vehicle to the outside of its system borderlines and to a receptor, this excluding products sold into a market.
- Removal of ores from nature into the system borderlines of a mining company - Elimination of weeds on a land plot by mechanical or chemical treatment done by the land user

NOT cases of Environmental Processes:

- Exhaust gas of a car penetrating into the passenger room thereby killing the car driver

- Transfer of goods or wastes from the control of one owner to the control of a next owner
- Spontaneous reforestation of an abandoned land plot (not an environmental process in our sense!)

D. AoP Manmade Environment

The trouble with AoP Manmade Environment is that it might be impossible to define the condition ("include damage only if caused by environmental process") in such a way that the damages/benefits to Manmade Environment will be restricted in the sense of (Udo de Haes et al. 1999, loc. cit.). I give some practical examples to show how AoP Manmade Environment could begin to dominate the LCA:

- LCA of herbicide use in a cornfield: Benefit to crops (AoP Manm.Env.) may outweigh damage to wild plants (AoP Nat.Env.)
- LCA of a river dam: Benefit to buildings downside the river may outweigh damage to aquatic ecosystems
- LCA of river re-naturalisation: Benefit to natural environment may be outweighed by loss of productive land
- LCA on shooting wild sows: Benefit to cornfields may outweigh damage to species diversity
- LCA on re-introducing wolf: Benefits to species diversity may be outweighed by damage to sheep herds

In my opinion, LCA is not an instrument for the comparison of damages/benefits to nature with damages/benefits in the economical system. The decision maker will find the necessary information on economic aspects outside of the LCA.

As long as nobody supplies practicable proposals for adequate limitation in LCA of damages/benefits to AoP Manmade Environment, I SUGGEST to freeze-in this Area of Protection.

Kind regards and my best wishes for the continued growth of your privately owned part of AoP Manmade Environment,

Ruedi

A10: Erwin Lindeijer, Answer to A9 (14 December 2000)

Thank you, Ruedi, for another very constructive contribution to this discussion. If I may reply:

Ruedi.Mueller-Wenk wrote:

A. Life-Support Functions: Mid-points or additional Areas of Protection AoP ?

I SUGGEST to keep Live-Support Functions at midpoint level as before.

Erwin Ad A: We agree with this, as can be seen from the last version of our paper d.d. this december.

B. Natural Resources: Depletion and Competition

I SUGGEST not to include the aspect of increasing/decreasing competition into the cause-impact chains originating from resource extraction. Increase of competition for resources is an important issue - but it will be considered by decision makers as one of the aspects outside of LCA results.

Erwin Ad B: This implies leaving out competition impacts from LCA's, parallel to leaving out the man-made environment (according to Ruedi both part of economy). Also according to the december version of our paper, we suggest to (try to) keep the distinction between economy and the environment clear. I suggest to do so by postulating possible consistent CONTOURS of system boundaries according to different perspectives (like strong or weak sustainability for instance).

C. What is an Environmental Process?

If we include not only emission impacts, but also impacts from extraction and from land use, defining an Environmental Process becomes rather tricky. I therefore SUGGEST to start modestly with a positive list (Cases of Environmental Processes) and a negative list (NOT cases of Environmental Processes), and I begin the 2 lists as follows:

Cases of Environmental Processes:

- Transfer of materials/energy emissions from a factory or vehicle to the outside of its system borderlines and to a receptor, this excluding products sold into a market.
- Removal of ores from nature into the system borderlines of a mining company - Elimination of weeds on a land plot by mechanical or chemical treatment done by the land user

NOT cases of Environmental Processes:

- Exhaust gas of a car penetrating into the passenger room thereby killing the car driver
- Transfer of goods or wastes from the control of one owner to the control of a next owner
- Spontaneous reforestation of an abandoned land plot (not an environmental process in our sense!)

Erwin Ad C: As the suggested criterium 'including environmental processes' does not seem very strong, the above list may not be valuable for defining system boundaries. I agree with Patrick that this may not work. I suggest to try to structure the possible consistent system boundary settings between environment and economy according to the abovementioned system contours proposal. Especially the more difficult border examples will help to show clusters of 'just within' versus 'just without' the economy matching these different contours.

D. AoP Manmade Environment

In my opinion, LCA is not an instrument for the comparison of damages/benefits to nature with damages/benefits in the economical system. The decision maker will find the necessary information on economic aspects outside of the LCA. As long as nobody supplies practicable proposals for adequate limitation in LCA of damages/benefits to AoP Manmade Environment, I SUGGEST to freeze-in this Area of Protection.

Erwin Ad. D: As I fear from previous discussions that discussions about what to in- vs exclude in LCA can not be solved easily. A step forward might be to not simply freeze in the Man-made environment, but include it in a clear discussion about system boundaries, maybe according to the suggestion above about system boundary contours? This will cost us quite some effort, I'm afraid. Either we find some funding for it, or someone knows someone else who can put some time in this next few months, or even years. Any suggestions?

Erwin

The Areas of Protection Debate: Phase B (pp 14-22)

Phase B relates to the [2nd Draft of the Areas of Protection](#) (mostly in January 2001)

B1: Erwin Lindeijer & Helias Udo de Haes (22 December 2000)

Dear active members of the SETAC WIA,

Apparently our previous draft has opened an interesting discussion area. Many reactions were already given. We have included them all as far as we agreed to do so. Now we have a new draft, and have included 13 questions for you! Not that we want to perform a panel weighting, but we would like to get as much constructive reactions, and get them in a structured manner, so we can try to deal with them for a chapter in the forthcoming WIA document, and maybe a paper in Madrid. So we invite you cordially to give this document a thought over Christmas, New Years eve or during other holiday events, and react according to the question numbers. We will draw up a new draft again by half of januari or so.

All the best for you coming year!

Erwin Lindeijer & Helias Udo de Haes

B2: Bo Weidema (26 December 2000)

Dear Erwin and Helias,

Thank you for including my e-mails and drawing as annex to your last draft. For a better understanding, I think it is useful to mention that (although I have maintained your word "society" in the small middle circle) my drawing and argumentation is based on the concept of the system as being "technosphere" (i.e. option 2 in your listing), while your argumentation rests on the idea of "society" as the system (option 3 in your listing). To regard human society as the system leads to endless problems and unnecessary arbitrariness as you already point out in your own text. Thus, I agree with Roland's argument in principle, and contrary to what you seem to think, this is also in accordance with the ISO definition of environment as everything outside the organisation studied (in this case the product system). Thus, in principle, the effects of the studied product system on other product systems are of concern in an LCA as a systems analysis. However, we usually deal with this as part of the inventory, simply by including the effects on other product systems into the inventory (by system expansion). Thus, from the point of view of impact assessment, effects within technosphere are neutralised, and we can view technosphere as one unity that impacts on its environment (which is option 2: technosphere is the system). Also from an outsiders point of view this is easy to comprehend: what we seek to do with LCA is to record and assess the externalities of the product system, both those externalities which are within society and those which are in nature.

Best wishes for the new year

Bo Weidema

B3: Patrick Hofstetter (26 December 2000)

Dear Erwin and Helias,

First, I wanted to thank you for the holiday greetings My holidays have been short (like Bo's) and in my case, it means that I did not have time to think about all questions. Therefore, I send you here my incomplete reactions. Unfortunately, I will start with an observation that does not easily fit into your question structure and is even somewhat fundamental:

Systems analysis versus decision support:

I think that much of the paper's discussion is relevant in terms of systems analysis (SA) but not necessarily when we speak about a decision support tool (I also interpret Edgar's reaction in this way). Systems analysis is very important to understand better how a system works, which parameters are related and whether there are causalities etc. In SA, it may be important to agree on physically measured versus monetary measured damage. It is also important to define upfront which processes are included and how big the black boxes shall be. All this can be decided by the analyst. Although there can be much said about the need for this type of systems analysis I believe that; type of LCA should support decisions on a product level. Therefore, decision makers and context decide on many issues you address in your paper.

Some examples:

Whether human health alone or together with other safeguard subjects is considered to have intrinsic values is not something we can know. As Beltrani pointed out, there are different fundamentally different points of view that can be taken (anthropocentric, ecocentric...). The decision context will also answer some of the question regarding the in/exclusion of certain causal relationships. If indoor air quality (or accidents or crop damage) is already captured by a separate analysis (using a more specialized tool) then LCA may not include this aspect again for efficiency reasons. For the same reason it may include these aspects if no other tools are used to consider them. Does this mean that Patrick wants to avoid further discussions by saying it depends? I guess no. I guess that I would like to avoid that the LCA is tailored in a way that allows only one path of future developments and creates inner and outer circles. In the past, we used the phrase LCA *sensu stricto* to indicate that there are other types of LCA than what we work on. However, some colleagues mentioned that these Latin words suggest again the idea of "real" LCA versus "would-like" LCA and even if this wasn't our intent I have to admit that the addition "*sensu stricto*" does not really specify anything about the type of LCA. I think that Gjalt Huppes thought more recently about the fact that we are about to create a multitude of LCA and started to create names for them. Although I hate the idea to take the economists as a model, I think that they indeed succeeded to use different names for their different models depending on which changes are considered and which not.

While this proposal helps a lot when we deal with indoor, workplace, frequent accidents, rare accidents etc. it may not look very promising for the WIA-2 when we have to decide about which safeguard subjects should be included or not and whether they have intrinsic or just functional values.

Who gives a first shot in suggesting which types of LCA the WIA-2 should differentiate and on which the group should work? Some reactions on the questions:

1. From a modeling point of view I might want to use this term on the level of the "ends", i.e., the level where changes are considered to affect the ends (safeguard subjects). This level can but does not need to be physical in nature.
2. Again from a modeling point of view (and I always refer to the decision support mode) I prefer safeguard subjects because this may imply a more stringent definition, is honest in its value-laden nature and implies the trade-ability that

we implicitly assume in LCA (fewer damages to ecosystems may compensate for increased health damages).

3. I guess that this may be too narrow (see some suggestions for allocation and suggestions on system boundary definitions by Rolf Frischknechts thesis).

4. In "my" systems world I used techno-, eco-, and valuesphere. Humans health is then part of the ecosphere and humans as observers in the valuesphere.

5-7. see general comment

8. (and text before questions). Of course, I agree with proposition 8 but I do not believe in (or understand) your statement that you would keep AoPs with only functional value even with perfect knowledge. If you would be able to predict all effects of changes in the product system on the AoPs with intrinsic values then you should do it to efficiently support decisions. In such a case you would be able to predict all consequences of reducing soil fertility or using highly concentrated resources. So, why should you bother about them? To avoid double counts you even would need to stop your modeling at the functional value level and disregard the additional information you have.

9/10. In general, yes, however, this may be just for one type of LCA

I know that some of these comments will send us on a longer journey than what you intended. However, parts of the work to be done will help to strengthen the whole framework of LCA, the possibility to communicate it within the science world and most important, to help decision makers to order the LCA they need or want to use.

I hope some of you are ready for this journey!

Best regards

Patrick

PS: Erwin, could you please keep track of all reactions you already got and will get and store them in a file? I think this may be valuable in case that somebody intends to put more work into these issues or wants to organize a workshop.

B4: Jane Bare (2 January 2001)

Erwin and Helias,

I have enjoyed being a silent reader for a while. I applaud you for initiating the discussion. I find myself being very much in agreement with Patrick on many issues in his attached letter, especially the fact that the overall framework was based on a systems analysis approach as opposed to a decision support framework. I agree with Patrick, Edgar, and others who recognize the value laden decisions being incorporated into each and every study decision, and I believe it is obvious how many of the issues that are being discussed here are value-laden. As a few examples,

- 1) We seem to be voting here on not only preferred terminology, but also what impact categories should be "in" or "out" (e.g., accidents, other human life issues?).
- 2) We are also voting on whether or not we should include the beneficial impacts that may be recorded within an LCA's inventory. I predict it will be extremely difficult to keep the "value" portion separated from the "science" portion in the upcoming SETAC- UNEP initiative meetings.

In the discussions on section 2, there seemed to be an obvious bias that LCA only should include "environmental problems," which was defined to include human health, but exclude car accidents because they do not involve environmental processes. This did not seem to follow logically to me. If an LCA showed that significant numbers of trees or wildlife were slaughtered in a "mechanical process" such as logging or accidents, wouldn't this be included? I consider it

excessively "eco-centric" to count dead trees and animals but not dead people. But again, if the goal is to produce an LCA that is "devoid of", or appropriately represents, various value choices, then one must allow the count to continue in both ways.

I, myself, like the idea of providing the most comprehensive list of all the possible impact categories, and/or endpoints to ensure that study commissioners are aware of the decisions made in these early choices. This "comprehensive list" is something a few of us here hope to work on within the next year, let me know if anyone has suggested reference materials to support such research.

Reactions to specific questions:

ad 5) I do not agree that we should exclude selected LCA impacts such as car accidents. As I stated above, I do believe these are value choices and not scientific facts to be determined by a scientific body voting on the issue.

ad 8) On the discussion of intrinsic vs. functional values...I find this to be a very vague and confusing differentiation which didn't clarify anything for me, since I can see both intrinsic and functional value in many things in my perspective.

ad 9) Yes, it appears obvious to me that if one is to be credited for doing damage, one should also receive credit for doing good. One U.S. company involved in Sustainability Metrics work has asked me before if they could receive credit within an LCIA for an area that they turned into a wildlife preserve. If the goal of LCIA's are "to support good behavior" then I believe that they should. But this brings us to an even bigger question: What is the goal of LCIA? Or is there one single unified goal? We have many questions that still need to be explored.

Again, thanks for initiating the discussions,

Jane

B5: Gjalt Huppes (4 January 2001)

Dear Helias and Erwin, and you all in the WIA group,

Some remarks to your WIA note of 22 December. I tend to place strong emphasis on the requirements for the central scheme, the circle, as this is (or becomes) the condensed form of the conceptual model. I have some main questions here, as to the meaning of arrows and as to the meaning of the rectangles/circles/areas.

Questions as to the exact boundary between environment and society ("till how deep does agricultural soil belong to society") are of a slightly lower order. There is one principal point here. Is this distinction society-environment indeed a basic distinction? Or do all detrimental effects of economic activities belong to the scheme, like worker's health effects because of working conditions. There is a vast economic literature on non-environmental external effects. I would prefer to stick to the society-environment distinction and then be liberal in adding non-environmental aspects to the integrated analysis, both physical, social, cultural, and economic, the last both market based effects and non-environmental external effects.

Arrows:

There seem to be two kinds of arrows in diagram 1. The arrow from natural resources to society represents a physical flow. It does not represent the causality leading to depletion. If that were the case the arrow would be from society to natural resources. In principle, I would first like to see the main causalities depicted, as resulting from all activities in society. Next, if indeed causalities are meant I would prefer the arrows to

go one direction only, with the exception of feedback loops. This is usual in systems analysis. We then are back at the original WIA multi-arrow scheme, which

of course may be condensed somewhat to convey the structure of the model more clearly.

Rectangles and circles:

Conventions in this area indicate a rectangle for processes, and ovals, parallelogrammes or circles for other things, like flows or states. 'Society' is a process, influencing its surroundings, so I would think. It then would be a rectangle. It is not the physical basis which is depicted there but the (mainly non-physical) social processes, with causal influence on its environment through physical-causal relations at its boundary to the environment.

The areas of protection have some ambivalence as to their exact nature. Human health may be interpreted as an effect category. For the other areas of protection it is the grouping of different effect categories. When grouping elements as to their main causal mechanisms, the causality is from society/economy to effects (at midpoint or endpoint level), not to areas of protection. This ambivalence was also present in the multi-arrow scheme. It can easily be amended there by defining areas of protection as the combination/sum total of a number of effects. Climate change and ozone

layer depletion then belong to life support aspects, at midpoint level, while they may also contribute to biodiversity losses, at endpoint level (with a nasty problem in evaluation resulting because of non-independence).

The causality is in the effect chains; not in the relations between areas of protection as groupings. Therefore, causal arrows between areas of protection as in diagram 2 may go in two directions simultaneously:

Biodiversity loss leads to losses in biotic resources while some types of (exclusive) land use may reduce biodiversity. The arrows then should not stop at the boundary line of some area of protection but to the miscellaneous effect types within it.

The life support system block indicates processes, like global warming, ozone layer depletion and acidification, so I would think. Human health and biodiversity are state variables, but may be formulated as changes to the state, eg as biodiversity loss. What resources are is not so clear. Extraction and the resulting depletion may be seen as processes; the stocks of resources are not. Land (or land use) is not very well defined in this sense. Land use is an environmental intervention, while land may or may not be part of the environment. If it is an environmental intervention, it is

the resulting effect on e.g. biodiversity which counts. It then does not belong in the scheme, unless environmental interventions were to be added to the scheme systematically. The causal chain is then that processes in society (or society as one integrated process) imply or lead to land use of certain kinds, which in turn leads to effects on landscape, biodiversity, etc.

Taken together, some further choices seem necessary before the scheme is refined enough to represent the central conceptual model. Main points:

- full clarity on the meaning of arrows, blocks and circles
- a choice for causality on the one hand and grouping in areas of protection in relation to evaluation on the other hand.

I really think it is important to have such a basic discussion as you started on the main diagram depicting the central conceptual model. I also like the introduction of the area of protection 'life support system', for the grouping of most or all midpoint effects.

Success with further development,

Gjalt

B6: Wolfram Krewitt (8 January 2001)

Dear Helias and Erwin,

Below some further comments on the LSS-discussion:

As said already during our Brussels meeting, I have some strong sympathy for the idea of giving more attention to life support functions in general, but I do have some major problems with the concept as it is currently discussed:

Definition of Life Support Systems:

Maybe that I missed something, but I haven't seen a clear definition of what is actually meant by the 'Life Support System'. Of course we all have a concept of LSS in our mind, and so we are ready to jump into the discussion. However, if we start to actually spell out what the life support system is, I expect that it will become obvious that there will be a significant (probably a complete) overlap with the 4 AoP defined in the earlier WIA-2 background document. I didn't yet think all this through to the end, but could you give examples of what are the additional indicators arising from the introduction of LSS as new AoP? We should carefully check if such indicators are not already covered by other AoPs.

I got the feeling that the introduction of LSS as AoP is very much driven by the problem resulting of incomplete knowledge/large uncertainty etc. in quantifying endpoint indicators in various areas. From my point of view this is not a good rationale for 'inventing' just another category within a conceptual framework which is structured according to criteria other than uncertainty. Lumping all the 'unknown' impacts into a new AoP does not solve the problem, and it does not reduce uncertainty or the lack of knowledge. Of course it emphasises midpoint indicators, but I don't see a strong reason for why we need a new AoP to give more attention to midpoint indicators. In the WIA-2 background paper we explicitly encourage the use of indicators on all levels of the environmental mechanism. From my point of view the problem is not that our current 4 AoPs (natural resources, human health, natural environment, man-made environment) do not cover the important impact categories, but rather that we have problems in bringing together in the final valuation step quantifiable endpoint indicators, quantifiable midpoint indicators (for impacts which are not quantifiable on the endpoint level), and probably also impacts that are not even quantifiable on the midpoint level. We all know that for various reasons people tend to stick to quantifiable endpoint indicators and forget about others. I have some doubts if we can really come around this problem by introducing a new AoP. I think the challenge is to find a way of including all the 'less quantifiable' impacts (which as far as I see are well covered already in our conceptual framework by the 4 AoPs) in the impact assessment and valuation process and make them more visible.

Does the introduction of LSS as a new AoP increase the consistency of the conceptual framework? Again, I have to admit that didn't think it through to the end, but my current answer is 'no'. It might happen in various cases that the same 'impact' on different levels of the environmental mechanism is allocated to different AoPs. I find this confusing.

As said in Brussels already, from my point of view the life support system is not on the same level as the other four AoPs. Our 'original' four AoPs might be considered as a first level of disaggregation of the very general life support system. If we ensure that there is no damage to the life support system, we don't have to care e.g. about human health or the natural environment (clean air belongs to the life support functions for humans). Again, LSS addresses midpoint indicators for other AoPs.

Specific comments/answers to your questions:

Can you agree with the use of the term "endpoint" in ISO 14042 sense (meaning elements at the level of physical damage)?

Yes.

Do you agree that Area of Protection is to be used rather than "safeguard subject"?

Yes.

Do you agree that system and environment are defined at the physical level, although the reasons to define a given system, and the evaluation of impacts on this system clearly will involve higher levels (i.e., the monetary level and the level of societal values)?

Yes.

Do you agree that as a default we should regard human society as the system (of which a given product system is a part), and that "the environment" relates to the environment of society?

I need some further thinking on what actually are the implications e.g. on indicators. I general I'd prefer Roland Clift's definition of system/environment.

Do you agree to exclude from LCA impacts which only involve processes within the system (without an environmental process), such as car accidents

No.

I would not a priori exclude anything that might be of interest in a specific context, and that might be quantified by using LCA methodology. In ExternE we quantified for example occupational accidents (e.g. coal mining accidents), which were quite important for some fuel cycles.

Do you agree to include impacts via environmental processes back on elements in society ?

Yes, of course.

Do you agree that types of impacts can be included or excluded consistently on basis of a fixed definition of the system and the system boundaries, or do you think that the boundary is at least in part application or context dependent?

I think they are partly context dependent.

Can you agree with the distinction between intrinsic values and functional values and also with the fact that AoPs can be identified on basis of both types of values?

I do not yet see the benefit or the importance of making this distinction explicit here (of course both intrinsic and functional values exist). What are the implications on e.g. the impact categories and related indicators?

Should we in general include positive side effects of environmental interventions in LCIA?

If so, should we also include side effects in LCIA, which have positive economic benefits?

I think we should not include positive effects of the 'soot (climate change' or 'NOx (ozone' type of effects, as I think we should not give any incentive for fighting an environmental problem by using other harmful substances (but we should make clear in the related documentation that we understand these positive processes). I have some doubts on whether Jane's example (area turned into a wildlife preserve) fits here, because the positive effect is not necessarily linked to the production of a commodity as such. In the case where we really have a positive side effect, then it is an allocation problem.

What do you prefer: only a diagram, only a table or both?

I don't see the benefit of the two dimensions in the table. Everything seems to get quite complicated. What are the actual implications on the impact categories/indicators? Why are there now so many new AoPs?

Which of the three diagrams do you prefer and why (we are not interested in votes, only in arguments)?

As I'm not yet convinced that the introduction of LSS as AoP improves the framework as such, I'm not very happy about either of the three diagrams. Diagram 2 is however closest to my understanding of LSS as a kind of higher level AoP: The outer circle becomes meaningless (it does not represent environment or anything else anymore, so it can be skipped), and the life support system is the fundamental basis for the other AoPs. However - as said before - I'm increasingly convinced that LSS should not be considered as additive or complementary to the other AoPs on the same level.

Should we change the term "man-made environment" into "man-made resources", because this term is not dependent on the precise definition of the system boundary (i.e., it can include elements which are back in society)?

I prefer man-made environment.

Wolfram Krewitt

B7: Walter Klöpffer (9 January 2001)

Dear colleagues,

in the last month of the 20th century an exciting discussion within SETAC-Europe's WIA-2 expert group has been started, induced by a modified scheme of Safeguard Subjects or Areas of Protection (AoP) by Helias Udo de Haes and Erwin Lindeijer. The main novelty of this scheme is the introduction of a new AoP "Life Support System", making sense if the AoP "Natural Environment" is taken as the living sub-system of the ecosystem earth and is characterized mainly by "biodiversity". The new AoP gives due weight to the "inorganic" and physical constituents of the whole ecosystem, e.g. the state of the atmosphere, the solar radiation and the bio-geochemical cycles which are, together with the quality of soil and water, the basis of life on earth.

The discussion has not been restricted to the new AoP, however, but rather resumed more general topics on the position, meaning and naming of AoPs and their graphical presentation in a scheme. This shows that some basic items have not been discussed exhaustively at the beginning and makes the open discourse so valuable.

I wish to comment on the relation of the "Environment" with something called "Society" by Helias and Erwin or "Technosphere" or the "Economic System" by others. The term "Environment" is poorly defined and has several meanings. In the context of our discussion it has at least three meanings, as already pointed out by several participants of the discussion:

1. System environment - everything not within the system boundaries chosen in a specific LCA. The system environment contains not only the natural environment (2), but also those parts of the technosphere which are not modeled
2. Natural environment - containing air, water and soil and the organisms living in these "environmental media", forming communities etc. Human beings belong also (but not exclusively) to this natural environment.
3. Man-made environments belong to the technosphere, but are open to the natural environment in different degrees (from the "work environment", e.g. in industry, to agricultural land, cultural landscapes etc.).

I got first aware of this definition problem in the late 70s when the German Federal Environmental Agency commissioned the Battelle-Institute in Frankfurt with the elaboration of criteria and valuation schemes for chemicals in the framework of the emerging chemicals legislation and as an input into the OECD working groups on harmonization of testing procedures. In order to avoid the difficulties involved in defining the environment as something separated in space, we "invented" a functional definition of the environment (Frische et al. 1982). We first defined the counterpart of the environment - everything what is controlled by human - and coined the term "**technosphere**" for this. The environment, in this definition, is simply everything not belonging to the technosphere, i.e. any process which is not or cannot be controlled by society. This is not the place to give examples for this concept, I only would like to mention that one important consequence of this model was the realization that, in the case of organic chemicals, persistence is the central environmental criterion, in the same sense as human toxicity is the central criterion for the assessment of chemicals at the working place (Frische et al. 1982; Klöpffer 1994; Scheringer 1999).

What can we learn from the functional environmental model for our discussion? I think that the AoPs Man-made environment and Human health have the closest overlap with the central "Society" - which should better be called "Technosphere" - and this should be shown graphically by an overlap (as shown in the scheme of November for the Man-made environment). Human health can be adversely affected from the environment and within the technosphere. If LCA stands for **environmental** Life Cycle Assessment, the former influence is more important than the latter. Human health and Man-made environments can be protected to a certain degree against adverse effects, nature can not or only indirectly at a long time scale.

The outer circle (in the scheme) symbolizes the **reach of human activities**. Since we already started to pollute the space around the earth and the nearest planets, we should not equal this border with the ecosystem earth (Lovelock's "Gaia") or, even more restricted, to the animate part of this system. The inclusion of the AoP Life Support System is certainly a step in that direction.

Finally, as an editor, I would like to ask the active participants of this discourse if you would allow me to document it in the free internet forum "Global LCA Village". Of course, the opinion of the "silent" participants is also highly welcome. I think that the high level of the discussion deserves a broader distribution and storage.

I hope you had a good start in 2001,

Sincerely yours

Walter Klöpffer

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The Areas of Protection Debate: Phase C (pp 23-43)

Phase C relates to the [3rd Draft of the Areas of Protection](#) and the [draft chapter \(8 February 2001\)](#)

C1: Helias Udo de Haes (1 February 2001)

Dear Colleagues,

Herewith I send you a reaction on your last comments. To be precise: in this round we received comments from Patrick, Jane, Wolfram, Bo, Gjalt and Walter. The text I send you now is still the same. But I have included short summaries of the comments, linked to the questions we had raised in the last text. After the groups of questions I have included notes about how I think that the text should be changed.

Erwin and I will now start to write a new text, in the form of a chapter in our coming book. If you can give further reactions on the included notes, please do, so that we can make use of them.

At the moment I am not able to include a new figure, describe how I think that it may look like. In fact I pretty much follow Bo's suggestions. But it may well be that the figure will be a point for intensive further discussion. And as Gjalt remarked, that is quite essential because the figure in fact summarises our top-down paradigm on LCIA.

I am interested to get further reactions. Erwin could at this stage give no input (due to incomprehensible electronic events), but the next step we will do together again. You will understand that we also are increasingly feeling the time pressure!

Best regards,

Helias

C2: Patrick Hofstetter (7 February 2001)

Dear Helias, dear all

Please find below my reaction to the latest draft of Helias from February 1, 2001, a reaction of Helias to my reaction and an answer from me at the end.

[Patrick wrote]:

Since you made clear that you now try to come to some conclusions for the chapter to be published soon, I will focus on two aspects only.

1. Systems Analysis versus Decision Support

You explain on page 4 (Notes) your reaction on my earlier comments. I like your example and assume that input variables in our case are the selection of alternatives to provide a predefined service and that output variables are (in EcoIndicator'99 language) Potentially Disappeared Fraction of species * m² * yr, DALYs, and surplus energy. In a decision support mode, both, input and output variables are finally chosen by the decision makers or their advisers.

In addition to the definition above, the paper tries now to limit the number of causal relationships between the inputs and outputs by adding, for instance, the requirement that we are looking ONLY on environmental impact that are defined as involving environmental processes. I agree that this is a possible limitation within systems analysis but I doubt its usefulness in decision support.

In decision support mode, I would guess that some other limitations are more important, e.g.,:

- I want only to include damages that occur outside of markets, or
- I want only to include damages that are carried by others than the one that cause them, or
- I want only to include damages that are not already compensated, or
- I want only to include damages that are not easier/more efficient to quantify by tool XY, or
- I want only to include damages where it is likely that ecotaxes could be introduced within the next Z years, or
- I want only to include damages where liability issues could become an issue, or
-

From this open list you see the potential starting points I consider to be relevant to decide on some of the issues we are discussing. Is this now more clear?

2. Functional and intrinsic values

If I understand right then you suggest to drop this distinction. If you do so, the framework becomes perhaps more acceptable because cultural differences in world views would matter less. However, the downside is that we would not know where we are interested in an additional information on causal relationships and where not. If human health is not an intrinsic value then we have to consider additional environmental impacts due to longevity and the related consumption. I am also convinced that a model to measure resource depletion looks differently for resources considered to have intrinsic or just functional values. Therefore, I would not skip this additional information.

[Helias answered]:

Thank you for your mail.

I think we come pretty close regarding the relationship between decision support and systems analysis. Two remarks about your examples for limitation of the scope. First, I think we should try to define environmental LCA. In ISO, LCA is defined within the framework of environmental management, i.e., the 14000 series! Then the elements which are damaged should lie in the environment, or be affected through environmental processes. But there is no problem to extend LCA to other types of impact. But then I see these as additional to environmental LCA.

My second remark would be that all kinds of further limitations (or: of focus) are possible. But I think that most of your examples should be dealt with in the Goal and Scope Definition. They are not generic, I would say. All, but possibly one which you do not mention: I think LCIA focuses on unintended impacts, on side-effects. Intended impacts are part of the defined function, and should not be part of LCIA. It may well be that this can solve the discussion with Ruedi: the intended economic impacts of a dam are important, but as part of the function which is to be provided, and not as part of LCIA. What do you think?

[Patrick's reaction to Helias]

Your reference to ISO seems to be a way to at least clarify that it is about "environment". However, demanding that the "elements which are damaged should lie in the environment, or be affected through environmental processes" does not limit but actually extend the scope of LCA (because of the "or"). I really believe that if we want to be more narrow than this then we need to define "Environmental LCA" following a principle that may be relevant for decision support. In your answer you make clear that you are not advocating to be more narrow than this => drop the limitation in the WIA text.

About intended/unintended: I agree with you, to include intended effects would make LCA very (too?) similar to risk-benefit analysis. So this may solve Ruedi's point. However, to include benefits and intended effects may be important in some cases and you may want to be careful in the wording.

C3: Helias Udo de Haes (8 February 2001)

Dear Colleagues,

Herewith we send you a draft text of the chapter on AoPs (and terminology). On the last text, which included your comments, we received a reaction from Patrick, asking that we should not drop the distinction between functional and intrinsic values. We have kept it, but have also indicated in the text that the distinction is useful but not sharp. Other new elements are: that we must regard the elements in the Life Support Functions as endpoints, and not as midpoints. Otherwise the LSF would be really at variance with the definition of an AoP (= class of endpoints). We propose now the term Life Support Functions instead of Life Support System, in order to indicate that this AoP is composed of different subcategories. And further we have added a new limitation under the Man-made Structures (formerly Man-made Environment, in line with Bo). This limitation is that LCIA deals with unintended impacts only; the intended impacts should be part of the definition of the function of the system, and therefore belong to the Goal and Scope definition. Perhaps it is the most useful if you focus your comments on the last section: the visual presentation. If we make a change there, it is our task to bring the rest of the text in line with that. But of course also other comments are welcome.

We propose to mention the written contributions. Have we forgotten any? We have now to start with the literature. Perhaps you can give us suggestions for additional references, which are not yet indicated in the text. We suggest that Ruedi and Olivier will review this chapter (although I have not yet asked them: can the two of you do this?).

Best regards,

Also on behalf of Erwin,

Helias

C4: Edgar Hertwich (9 February 2001)

Dear Helias, dear Erwin,

Thank you for stimulating a very interesting discussion about Areas of Protection, which is one about the motivation for doing LCA. I think your paper presents an interesting argument about how to reason about values and their role in the assessment, an argument about what to take into account.

I am worried, however, about publishing this as part of a guidance or "state of the art" document. We all value different things for different reasons. While it helps clear thinking to reason this through (a largely philosophical activity), I don't think we can, nor need to, agree on these lines of reasoning. My reasoning is different from yours, as you may see from my paper "A decision-analytic framework for impact assessment" (I send the second part of this paper in a separate mail only to you). But this does not worry me, we need to agree only on actions, not on motives. I think your paper, and mine, present alternative but rational ways of structuring impact assessment.

So my concern about including your piece in the working group report is that it is too normative, it bears the danger to overdefine and restrict LCA. The motivations and values of an LCA should be defined in the Goal & Scope. WIA2 offers guidance on method choice; while the methods are designed for a specific purpose, with a specific AoP in mind, it is only necessary to state this purpose, not to prescribe that all LCAs need to be done for this purpose.

My second point is question: how is LCA related to (i.e. different from or the same as) a very comprehensive benefit-cost analysis? Some LCAs, e.g. those conducted at IER in Stuttgart, are very similar. Others, by my colleagues here in

Norway, are very different. If we go towards damage modeling, I do think economics offers an internally consistent framework which resolves many of the issues you address. What you seem to argue is that there is something else out there which does not fit into the calculus of benefits and costs, something more fundamental. I fully agree and point to the fact that this is common in ethics, law, etc. There are fundamental norms of behavior and rights which are not subject to benefit-cost considerations, such as freedom, the right to life and property, etc. You argue that life support functions are such a basic good that they deserve such a status. I do think that this is what also underlies the idea of sustainability. The debates about sustainability should be referenced in this connection. I would suggest that LCA should be a separate instrument, but that economic valuation is a permissible (and interesting) valuation method that can account for some but not all concerns we have about the environment. Other valuation methods, based on "midpoint" indicators, may better account for life support functions and unpredicable damage.

Thirdly, under which AoP does Non-biotic nature (glaciers, petrified wood and animals, the clear view in the Grand Canyon) now fall?

There are some minor comments and editorial suggestions which I noted in the "comments" and "revisions" modes in the document and which I send separately only to you.

Thanks for your attention,

Edgar

C5: Walter Klöpffer (11 February 2001)

Dear Helias, dear Erwin,

thank you for sending around the draft of the Chapter "The Areas of Protection in Life Cycle Impact Assessment" and asking for comments, especially with regard to the graphic. I think, the draft reflects fairly well what has been discussed in the last two months. As mentioned in the text, it is really difficult to present graphically the compromise, especially if the presentation chosen is symmetrical, as it is. The different AoPs or safeguard subjects are, of course, not symmetrical with regard to the central Technosphere. The "Man-made Structures" and "Human and animal health" strongly overlap functionally with the Technosphere, the "Life Support Functions" weakly, "Natural Resources and Biodiversity" are perhaps in between.

With regard to the partly new wording, I have no difficulty with "Life Support Functions" (I also agree that there are biological components in it, if the previously used broad term "Natural Environment" is now reduced to "Biodiversity").

The term "Man-made Structures" is certainly not wrong, but "structure" has also the meaning of "building" (including technical buildings like bridges, dams etc.). There is a certain danger that readers will think that actually only such buildings are meant. English native speakers, please comment on that point!

With regard to the AoP "Human and animal health" I would like to ask again the native speakers: is it clear enough that "animal health" refers to domestic and useful animals only?? Or do we include here the animals living "in the nature"?

The term in the center (now: Economy (technosphere)) should in my view read "Technosphere" alone, not only since the term was coined by "my" team at Battelle (Frische et al. 1982), but since it has only one meaning: the counterpart of the environment, and that's what is meant here. Economy, on the other hand, has 4 meanings as a substantive (noun) according to The Concise Oxford Dictionary (8th ed. 1990):

1. the wealth and resources of a community
2. the careful management of (esp. financial) resources
3. sparing or careful use
4. economy class in air travel

Webster's Encyclopedic Unabridged Dictionary of the English Language (1989) lists nine meanings of economy as noun:

1. thrifty management, frugality in the expenditure or consumption of money etc.
2. an act or means of thrifty saving
3. the management of the resources of a community
4. the prosperity or earnings of a place
5. the disposition or regulation of the parts or functions of any organic whole
6. the efficient, sparing or concise use of something
7. economy class
8. (Theol.) the divine plan for man...
9. (Archaic) the management of household affairs

None of these meanings fits exactly what we understand her in this context. The word "technosphere" is a neologism and as such not contained in the two dictionaries consulted. The same is true for the original German "Technosphäre" and the comprehensive edition of the "Duden".

Best regards

Walter

Reference:

Frische, R.; Klöpffer, W.; Esser, G.; Schönborn, W. (1982): Criteria for Assessing the Environmental Behavior of Chemicals: Selection and Preliminary Quantification. *Ecotox. Environ. Safety* **6**, 283-293

C6: David Pennington (12 and 13 February 2001)

Walter,

For me, "man-made structures" only reflects the concept of bridges, buildings, statues,

For "human and animal health" you may want to check on the exact definition of "animal". It covers both domestic and wild animals, of course. But, the animal kingdom does not cover all living species - plants, bacteria (?), ... - I think, but you would need to reconfirm with a biologist. We have been using the term "ecosystem health", as this appears to cover all living species in the wild. It does not, however, cover domestic pets, at least explicitly.

(In response to Edgars comment, maybe Helias et al. would consider publishing their article in the J.of LCA or on the LCA Village site??)

David

P.S. Sorry I have not been able to follow the AoP discussions in detail more recently but hope these responses are still of some help.

David, February 13

Be careful with the term "biodiversity" - it probably better reflects a count of species rather than an explicit measure of the state or quality of the ecosystems (may be somewhat an implicit measure in some cases?).

Can you also elaborate on the problems with the term "ecosystem health"? (which includes biodiversity as one of the possible indicators, or subcategories) It is maybe correct to state that an ecosystem is not a single living entity, although this can be debated both ways. It is, however, also correct that we may not always be interested in biodiversity - we may increase biodiversity by altering a habitat (part of an ecosystem that is not living) but at the same time lose a species of interest.

I would be very reluctant to try to relate, or want to relate, current ecotox measures in LCA to biodiversity alone - such a relationship can be discussed in the context of some of the species sensitivity distribution (SSD) measures such as PAFs or PDFs, although not without problems. Is it really a measure of species loss that is desirable or a measure of the health of species. Do we care only if a species exists or not, or more weather less than 50% develop tumours, ...??

For animals, this is a defined kingdom and not only limited to domestic species, pandas, whales, eagles, ...(and all wild species). It does not, however, include plants, Maybe this is what you want.

Just some thoughts,

David

P.S. Side comments: Without having seen the latest categories, I would like to note that humans are still part of the animal kingdom and their health should be a subcategory of this protection group. (we are probably better at ensuring rodent health rather than human health anyway!!!)

C7: Erwin Lindeijer (13 February 2001)

Thanks for your inputs all the way through, David. I agree the term biodiversity needs clarification if we introduce it; I had not yet discussed this with Helias. Interesting to relate ecotox to species health; would this be captured under wildlife welfare (as additional to domesticated animal welfare)? For me, wildlife welfare is an intrinsic value related to species (including fauna and flora), and may even include individuals (a very old tree?), which should be part of the old ecosystem health but more explicit as subgroup under biodiversity (in our and UNEP's definition). Thus species health is for me a subset under a broad definition of biodiversity.

C8: Wolfram Krewitt (13 February 2001)

Dear Helias, Erwin, and all the others,

Thanks for the new paper. I think it is a very good synthesis of the previous discussions, and helps a lot in clarifying the discussion.

I like your new version of the diagram, in particular as it gives the message that the Life Support Functions are the basis for everything else. (A minor point: I suggest to leave a little bit of space between the 'natural resources' and the 'biodiversity' boxes, just to not raise the impressin that they are directly linked to each other.)

I still strongly disagree with adding the Life Support Functions as an additional AoP on the same level to the other AoPs. Which are the elements comprising the LSF? You say: 'the main natural regulation functions, particularly those dealing with climate, the hydrological cycle, soil fertility and the bio-geochemical cycles. So those dealing with air, water and soil, and with substances'. Well, then it basically covers everything! I still see the LSF-endpoints as midpoints to all the other AoPs.

I do not follow your 'we should not disrupt the climate ==> societal value' argument as a claim for an additional AoP. Also statements like 'we should not

pollute the air' or even 'we should not emit radioactivity (or dioxins, sulfur, ...)' appeal to society without regarding the precise consequences, and we do not conclude that we have to add new AoPs related to all these statements (of course, finally they are all related to life support functions). Perhaps I have problems with the definition of endpoints. Following the current definition, something is an endpoint if it is 'directly relevant to society'. The question is what 'directly relevant' actually means. From my point of view your use of the definition somehow suggest that midpoints are not relevant to society at all, a conclusion to which I strongly object. As I said in my earlier comments, I'm very much in favor of 'upgrading' the importance of midpoint indicators, but I do not think that this requires a new AoP.

Table 1: I do have some doubts on whether biodiversity has an intrinsic value only (from my limited understanding there is also a clear use value), and on whether life support functions have a functional value only.

I can accept the term 'man-made structure', but I'd still prefer our old 'man-made environment'. I see the problem with the definition of the environment, but I think the term 'man-made environment' is not completely incompatible with the definition. 'Man-made structure' is perhaps more precise, my main concern is that it is difficult to understand by people that did not follow all our discussions (I think the wording suggests very much a focus on materials/buildings).

I like your clear statements with regard to the discussion on DALY/QALY as midpoint/endpoint indicators!

Regards,

Wolfram

C9: Helias Udo de Haes (14 February 2001)

Dear Colleagues,

Again we received interesting input. As a whole we learn from the comments, that we are converging; the text gives a good overview of the discussion and the diagram gets support. But there are still some main topics of disagreement. These are:

- Is the chapter not too prescriptive? Or do we indeed need a default?
- Is LCIA not becoming too broad, if we include Man-made Elements (or other term)?
- Are the Life Support Functions an AoP of themselves? Or are they indeed of another character than the other AoPs?
- Some critical terminological issues (economy, human and animal health)

I think we must realise, that in the short time period which is left, these issues cannot be fully solved. We will try to clarify these remaining differences as good as possible.

Below we give the main comments made, together with suggestions on how to cope with them. I also include comments made by Erwin, because these are just part of the process.

Title

- broaden the title; include "development of framework for LCIA" (Erwin) (suggestion: agree)

1. Introduction

- do not forget limitations set by LCI database (Ruedi) (suggestion: agree)
- need for a default type of framework because of databases (Ruedi) (suggestion: agree)
- objection against too normative character of the total chapter (Edgar) (we asked Edgar to give well recognisable input, for instance as epilogue to clarify his point as to present his alternative)
- number of textual improvements (Jane) (all agreed)
- make positioning clear in relation to CBA (Edgar) (suggestion: this is outside the scope of this chapter)
- agreement on the role of analytical tools for decision support; environmental LCA should focus on environmental impacts, but LCA in general can be of course broader (Patrick)

2. System and environment

- define "environmental process" (Ruedi) (suggestion: agree: all processes between interventions and endpoints)
- "technosphere" as a term better than "economy" (Walter) (suggestion: although we recognise that the term "economy" is multiple, we suggest not to follow this because "technosphere" is distinct from "valuesphere" (Hofstetter, PhD), and in the last round we concluded that we should not make a too sharp distinction within the system itself between the physical processes and the financial and social processes; but we agree that we must more clearly define "economy")

3. Further terminology

- endpoints not clearly defined; what is "direct concern to society"? (Wolfram). Better "ultimate concern"? (Ruedi) (suggestion: we will do our best)

4. System boundary and man-made environment

- man-made environment as an AoP: how to limit LCIA? proposal: non-economical; so: only include cultural heritage, and not damage to commercial buildings (Ruedi) (suggestion: not to exclude all economic damage; if LCIA becomes too broad, make a more limited positive list)
- try not to define too precisely, but seek solution in positive and negative lists (Ruedi) (suggestion: agree)
- not "Man-made Structures" as a term because too much stone or concrete (Walter and David); and preference for Man-made Environment as term (Wolfram) (suggestion: agree that "structures" is too hard; perhaps "Man-made Elements"?)
- try to split up Man-made Structures (or: Man-made Elements?) in a consistent way (Erwin) (suggestion: for further work, now beyond scope)
- plea to keep distinction between intended and unintended, although perhaps not fully sharp (Patrick) (suggestion: agree)

5. LSF

- explain "biodiversity" (David) (suggestion: agree, in line with Rio Biodiversity convention, with distinction between three aspects)
- make reference to sustainability debate, in order to get better foundation of LSF (David) (question: David can you give us the precise reference and a text proposal for making this reference?)
- show what the problems are with the term "ecosystem health" (David) (suggestion: can be done; this term seems also to include the LSF and can therefore not easily be used in contrast to the LSF)

- support for term "LSF" (Walter) (thanks)
- objection against LSF as AoP; then also "clean air" an AoP (Wolfram) (suggestion: not agree, but bring this point more as an option and tell there is also another option; we do not agree (as yet) with Wolfram because there is a difference between clean air, as absence of pollution, and the positive presence of regulation functions; but this should be better explained; we see the distinction between intrinsic values and functional values as very relevant here; to our opinion "resources" and "LSF" are pretty close; land (or at least soil) and water can be seen as resources, but also as LSF; so: if we have to remove LSF as AoP, then also the resources should be out, because these are also of intermediate value); but the last word is surely not said on this interesting issue
- clarify that in LSF more impact categories (as is also true for other AoPs) (Erwin) (suggestion: agree)
- include Natural Landscapes, because these are now forgotten (David) (suggestion: agree)

6. Visual representation (rather: Overview?)

- human health part of health of all animals (David) (suggestion: because LCA gives as yet so little attention to animal welfare, just state in the text that also animal welfare should in fact be seen as part of a broader AoP, including both human health and animal health; "human health" is pars pro toto)
- make clear that only welfare of domestic animals is involved (Walter) (suggestion: agree that not all animal suffering can be included, only as far as it is caused by humans; but then also to wild animals; so only attention for unnecessary and disproportionate suffering caused by humans; for instance to seals, whales, etc.)
- support for the diagram (Wolfram; and also by Walter, regarding the structure of the diagram) (fine!)
- distinction between intrinsic and functional values is not 100%; biodiversity in part also functional (Wolfram) (suggestion: we can say: "mainly"; but the functional value of biodiversity may well be part of the LSF)
- "resource functions" instead of "resources" (Erwin) (suggestion: not agree; it are the resources themselves which are relevant)
- in the diagram there is a third dimension: from physical processes via financial processes to social processes; suggestion to include this (Erwin) (suggestion: agree with the idea; we can state this in the text, but for later elaboration in the diagram)

7. General conclusions

- should be added (Erwin) (suggestion: agree)

I hope that we can soon send you the next version, which should be more or less the final draft, in view of February 15.

Also on behalf of Erwin,

Helias

C10: David Pennington (14 February 2001)

In addition to comments made directly related to the diagram and also some of the terminology, I would now like to add the points below related to the draft. Firstly, unless changed, I agree with some of the other opinions that there should be caution in adopting this manuscript as a chapter. It is very much a proposal of ideas, many not shared by other practitioners. As such, and if it is to be included as a chapter or an appendix, it should really be worded in the way of a discussion with

Suggestions/proposals. At this time, the draft appears to make statements that will be adopted in the future - rather than providing suggestions or a proposal as the basis for future discussions. I also feel that there is a strong need to reconsider/re-address terminology that is now being proposed, or stick with the already established

Terminology. Below I outline some specific concerns, in addition to those recently made related to the diagram and terminology.

- 1) In the first sentence of the introduction, it is stated that LCIA has the mission to link interventions from the LCI to elements valued by human society. Firstly, this is somewhat hard to follow - please define terms such as "interventions" or state what is truly meant - emissions and resource consumption, ...?? I note that a definition is given later, in the middle of section 3. Similarly, does LCIA really only address issues as valued by human society???? Or, do we try to go beyond our self interests Appears to be a very philosophical area for debate, which may be best avoided in such a statement defining LCIA!
- 2) It is not clear (paragraph two) that midpoint approaches have structured the thinking in the current working groups and definitely unclear that this should be the case in the UNEP-SETAC initiative. (Note: Midpoints and endpoints appear to be well defined in relation to cause-effect mechanisms; noting that there can be many endpoint measures such as counts of species losses or number of species affected by different types of malady,)
- 3) Section 2, paragraph 2: There is a strange use of the word "environment" in this section. I believe that you are discussing the system surroundings, i.e. the surrounding environment or the environment that the system finds itself within. To ask "what is the environment of the system" appears to be awkward to me. This is even more difficult to comprehend when terms such as "the economy and its environment" are introduced as the core of an LCA. The move to the idea that we are interested in the economy and its environment when, in reality, we compile emissions data and resource consumption data for a web of unit operations is unclear, and maybe misleading. There is already enough trouble distinguishing between LCA and Life Cycle Costing, I'm further sure that we all imagine very different things when we think of the environment of an economy. The word "technosphere" remains more interesting, although not without serious problems. How about something that better reflects "anthropogenic interventions"?
- 4) Similar to point three, are we considering a defined system and its environment, or a system and its surroundings, or "surrounding environment" - note the latter can imply what is around it and not necessarily everything outside of the system boundary. Such as the surrounding environment in my office!
- 5) Section 4: I have difficulty with the idea of this document trying to establish what should and should not be in the scope of an LCA. Just because some practitioners have not so far considered accidents, for example, does not mean that they should not be part of an LCA. They are a key factor related to human health - transport of dangerous chemicals, personnel, ... If one chain of unit operations requires greater transport than another then this will have direct impacts to human health, wild life and land use beyond just those associated with the emissions inventory. This kind of decision (what is included) should be an explicit choice in the scope of an LCA. I suggest that this manuscript only tries

to address the structure and categories of LCIA, rather than trying to dictate what should or should not be in an LCA. Alternatively, it should be written in the way of suggestions or a guidance.

6) Para 4, section 4: "intended impacts should be part of the function of the system, and consequently not part of the LCIA" - nearly all resource consumption and emissions can be considered as designed parts of the processes addressed, hence intended - leaving what to be addressed in the LCIA? We may therefore only address fugitive emissions in LCIA, although these could also be considered "designed-for", as the associated risks of such events are often accounted for in the design of a process.

7) second section 4, para 3: Was it really the intention of Patrick's unknown damage functions to represent life support systems? I had interpreted this to be more a measure to try to account for what we do not know, say a broad precautionary principle measure. For example the use of measures such as a chemical's persistence in the environment and quantity released to provide insights into whether a "human damage factor" is all encompassing.

8) Soil fertility may be a desirable consideration, but is also achieved in many modern practices through the application of fertilizers, sewage sludge, ... This is also a part of the man made environment, in some cases.

9) Life Support Systems are a new proposed AoP, and should be presented in this way until general consensus has been reached.

10) Diagram - comments already made; related to the idea of separating animal health, biodiversity, ... I strongly suggest the adoption of a well established term such as "environmental health" with subcategories such as biodiversity, life-support systems, Human health could be maintained separately, noting the interaction. Otherwise the structure of LCA will remain ad-hoc and will continue to be attacked by many critics. (As also stated, biodiversity has a specific meaning and is only one area of protection or measure under the heading of environmental or ecosystem health. Biodiversity does not account for 50% of the adult fish in a river having tumours, for example. I don't believe that the count of species is as important as their health, similarly for the human population. I also do not believe that low biodiversity implies an ecosystem that is not healthy or in a natural state.)

Hope all this helps. LCIA needs a well-defined basis for the categories that are considered and, with a little more work, this chapter has the potential to provide the initial foundations for such a basis.

Thanks,

David

C11 Olivier Joliet (14 February 2001)

Dear Helias,

Here are some comments (excellent progress until point 4 for me apart some small comments on cars and smoking) and new ideas on the way to group area of protection. I am very interested to hear your reaction. Shall I distribute it to all other persons or do you want some bilateral exchange first ?

Main points on part 5: Here I really start to have some problems with these 5 AoP:

a) Animal health is suddenly introduced as a separate Area of protection (not discussed at all above) that you group with human health. Please keep at least separate from human health as we generally do not try to protect them at the same level. Why not couple it with biodiversity, as the physical being is the same: may I suggest to have 3) ecosystem&animal health and biodiversity.

b) The question of biotic resources and its strong link to biodiversity remains a problem. Could we not try to also link them.

May I suggest to group the AoP by "physical safeguard subjects, with in each safeguard subject 2) and 3) some a) intrinsic and b) functional aspect", as follow:

- 1) Human health
- 2) Biotic environment (excl. humans)
 - a. Biodiversity (including genetic, species and ecosystem diversity), & perhaps animal health
 - b. Biotic resources
 - c. Crops
- 3) Abiotic environment
 - b. Abiotic resources (land+minerals)
 - c. Man-made structures (materials, buildings and works of art)
- 4) Life Support System (climate regulation - hydrological cycles - soil fertility - bio-geochemical cycles)

2c) and 3c) could be grouped in a separate man-made structures. But the distinction between crop and biotic resources is really small, apart the fact biotic resources are at least this grouping according to "physical being could be clearer, as there is no overlaps between 1,2 and 3.

I am looking to have your comments on this proposal... eventually showing the dark points of this brilliant idea you have perhaps already tried!

C12: Bo Weidema (15 February 2001)

Dear Helias,

Olivier comes up with a really different diagram on the AoPs. He is nice in that he says that he likes the preceding text, but in fact if you take his classification of the AoPs, you should write a different preceding text. Because following his classification you do not arrive at the Man-made Environment (or whatever term) and the LSF as AoPs. But I think that this difference can be changed to an interesting point. As I see it now you can define the AoPs in a bottom-up way (classifying elements in the environment) or in a top-down way (starting from the societal values). Then what Olivier proposes follows the first route: human, biotic, abiotic. What Erwin and I have done start from the societal values. For instance the distinction between functional and intrinsic values; and the distinction between natural and man-made. I think that it is very relevant to show that there are two ways of doing this. And this can then be clarified by presenting two diagrams, one with our proposal and one with Olivier's.

1. I agree that Oliviers' approach is possible, but is it meaningful? If the purpose is an assessment, you have to end up with something which is useful in terms of societal or intrinsic values. Lumping together biodiversity, ecosystemhealth and animal health into one group just because they are all biotic is not meaningful unless you can attach some kind of societal or intrinsic value to this group. To do this, you would anyway have to split it up into its resource aspects (biotic resources and biodiversity), its life support functions (ecosystem health) and welfare of individuals (animal health). Thus, I would challenge Olivier to justify his approach more before accepting it as an alternative approach. (Please note that I agree that animal health is a misnomer when placed in parallel to human health. That is why I have suggested to call this AoP "Health / welfare of humans and animals in human care" - by adding welfare, we do not focus on health alone, nor do we specifically express how to treat intentional deaths).

2. The other point is that David suggested to make a distinction between "surroundings" and "environment". This is interesting. In the framework of systems

analysis we can speak of a system with its surroundings. In the framework of LCA (as part of the environmental management series) we speak of the environment. And then we try to match the two: "environment" can be seen as the surroundings of the economy/technosphere-system. Environnement is the latin term for surroundings (german "umwelt"), i.e. you are addressing synonyms.

3. Thirdly: what about a preference for Man-made Environment, Man-made Structures or Man-made Elements?

I agree that structures are too rigid, and find elements too elementary, thus I prefer "Man-made environment" if you cannot accept the more precise "Man-made structures and ecosystems".

Helias, my "reply all" button is malfunctioning, so would you please forward this e-mail to the rest of the group? Thanks.

Best wishes

Bo Weidema

C13: James A. Fava (15 February 2001)

I will like to state right from the start of my comments that I have not really engaged myself into the details of this debate and discussion nor have I read the paper being debated in any detail. However, having said that do have a few thoughts.

Edgar brings up an important issue - what is meant by state-of-the-art? Is it practice performed by the top 2-5% practitioners in the field; is it what all the practitioners currently do, or is it what the leaders would like everyone to do, or some other expectation? I think experience and general acceptance by the scientific and user community will provide insights as to best practice. We should continue to advance the practice and not put our head in the sand or not endorse new ideas which will advance the practice of LCA. We must realize that LCA is a new tool and advances and experience with his use worldwide is only recently becoming more widespread - we want to continue to advance its use - not inhibit its use. There is a balance that must be met, and the line is not clear. However as leaders in LCA, we all have interest,

1) to advance the overall value and usefulness of using a life cycle approach; and
2) improve the tool itself.

We cannot do one without the other - but moving too far on 1 interest without moving also on the other will reduce our effectiveness.

- I encourage and fully support positions and papers that advance the thinking on impact assessment. Apparently Edgar has some ideas as well. All of these should be published, tested, improved through actual experience and use, and through scientific discourse in the public forums and published journals, etc.
- Given the amount of excellent interest and debate - I would say that we do not have universal acceptance that the proposed path is acceptable to all and should be followed in all LCAs with respect to AoP.
- Given that we want science to help advance the field of LCA - establishing boundaries on how an impact assessment should be completed when we are at such an early stage in LCIA development (only conceptually defined in early 90s) appears to be premature. We should however provide insights and vision to stimulate thinking and creativity so as to advance the practice. Perhaps this vision (AoP) should be published as such - a vision, which reflects some additional ideas but which is too early in its development to be called state-of-the-art. This publication could be used to stimulate additional research.

If I am out to lunch because I got involved late and perhaps do not fully understand the context - please disregard. However, I do think the debate on what represents "best practice," "state-of-the-art," or "state-of-the-practice" is one, which will continue as we advance the UNEP/SETAC Life-Cycle Initiative. Have a good week. I am out until Feb 19th.

James A. Fava

C14: David Pennington (15 February 2001)

Your plan to be less prescriptive and to present multiple options is most welcomed.

There appear to be some options missing from your email that were proposed by others, including by myself, although I am sure that these will be captured in your next draft of the chapter.

In response to your three specific questions:

1. Have you specific ideas on the term "environmental intervention" as opposed to "environmental exchange"?

I don't mind interventions, and in fact proposed the term "anthropogenic interventions" along with the discussion in my last email. I am not sure that it is the environment that is doing the intervening, but this may not be important.

2. Can you agree that the distinction between "system with its surroundings" vs. "environment" is clarifying?

Still have problems with the idea "economy and its environment." The idea to specify the environment that is being discussed is appealing, even if it is only a replacement word for surroundings or what is outside of the studied chain of processes. (or do you mean "The Environment") My concerns related to "economy" were also expressed in the previous email.

3. What do you prefer: Man-Made (MM) Environment, Structures or Elements?

MM Environment appears to imply everything around us that is not natural. Structures would probably be a subset of that and exclude things like fields (?), Elements appears inappropriate. Is there a better term than "abiotic or anthropogenic environment"??

David

C15: Helias Udo de Haes (15 February 2001)

Dear Colleagues,

Ahum, Well, what shall we do? Patrick, thank you for your compassion! I will first give some comments, and then come up with a proposal. Due to the time shortage I do this with only limited exchange with Erwin, so Erwin, please feel free to disagree!

I start with David's comment that the text should be less prescriptive. I can agree. Of course I like the text, but I realise that there are other options. So the text should clearer show alternatives.

I directly give one example. Olivier comes up with a really different diagram on the AoPs. He is nice in that he says that he likes the preceding text, but in fact if you take his classification of the AoPs, you should write a different preceding text. Because following his classification you do not arrive at the Man-made Environment (or whatever term) and the LSF as AoPs. But I think that this difference can be changed to an interesting point. As I see it now you can define the AoPs in a bottom-up way (classifying elements in the environment) or in a top-down way (starting from the societal values). Then what Olivier proposes follows the first route: human, biotic, abiotic. What Erwin and I have done start from the societal values. For instance the distinction between functional and intrinsic values; and the distinction between natural and man-made. I think that it is very relevant to show that there are two ways of doing this. And this can then be clarified by presenting two diagrams, one with our proposal and one with Olivier's.

We also will make another step to clarify the exploring character of the chapter. As Edgar wrote that he found the present text too prescriptive, we have asked him to write an epilogue after the chapter. He agreed to do this. My opinion is that it is better in this stage to have a clear presentation of different viewpoints, than to have no presentation at all.

Because, although the discussion is surely not finalised, we are much further than we were. At least in identifying critical issues.

So, taken these three points: in general writing more in the form of suggestions, two diagrams instead of one, presenting different ways to define AOPs, and an epilogue, I think that the new text can be included as a chapter. Also David's last mail fits well: he supports Olivier's proposal, which will be included. The place where in the book (in the beginning or in the end) I propose to leave to the reviewers (Olivier and Ruedi, not me of course). I think we can wait on this point until the new text plus epilogue is ready.

Now just three more issues, related to terminology, two of them on basis of David's and Patricks remarks.

1. the term "environmental intervention" (is emissions, extractions, land use). I know that the NA people do not like it. That was the reason to put this clearly on the table, about two months ago. The outcome was: there is no good alternative. Bo had suggested "exchanges". My problem was that the term "exchanges" will have two meanings (also: data exchange format, i.e., between databases). An option could be: "environmental exchanges". (Then we would have the same as with "normalisation": "FU normalisation" and "normalisation in LCIA"). This surely is an option. Who has a strong opinion here? Keep "environmental interventions" in line with our earlier publication and change perhaps in UNEP framework, or change now to "environmental exchanges"?
2. The other point is that David suggested to make a distinction between "surroundings" and "environment". This is interesting. In the framework of systems analysis we can speak of a system with its surroundings. In the framework of LCA (as part of the environmental management series) we speak of the environment. And then we try to match the two: "environment" can be seen as the surroundings of the economy/technosphere-system.
3. And thirdly: what about a preference for Man-made Environment, Man-made Structures or Man-made Elements?

Taking as accepted (I hope on good grounds) that you can agree with the above proposal on how to write the text for the chapter, plus the epilogue from Edgar, my specific questions are now:

1. Have you specific ideas on the tem "environmental intervention" as opposed to "environmental exchange"?
2. Can you agree that the distinction between "system with its surroundings" vs. "environment" is clarifying?
3. What do you prefer: MM Environment, Structures or Elements?

As always, best regards,

Helias

C16: David Pennington (16 February 2001)

Thought it would be useful to have a look at the book "Basic Ecology" by E.P. Odum this morning. In the scope he (she?) defines terms such as ecology (interestingly having the same greek origin - oikos - as economy - which translates as "household management" - oikos nomics!). It appears that ecology is the study of the environmental household including all organisms and all the functional processes

that make the household habitable. Anyway, now knowing that economists and ecologists are doing the same thing, I get to the point:

Ecosystems are then described - living organisms in their nonliving (abiotic) environment (with interactions). The biosystem and biosphere (sometimes termed the ecosphere) are mentioned, along with terms such as the biotic community (an area of protection?). Such biotic communities that interact with physical environments so that energy flows lead to clearly defined biotic structures and cycling of materials between the living and nonliving parts are ecological systems or ecosystems.

Based on the famous Lovelock and Margulis, we have the abiotic world (nonliving) consisting of the atmosphere, hydrosphere, geosphere and then the important biosphere - living world (without which we would be like Venus; and which includes humans). The ecosphere is the interaction of all these spheres (presumably including life support systems such as the water cycle, ...).

In brief, it appears that there are many well-defined and useful terms out there that we can adopt in LCIA to describe areas of protection or safeguard subjects. These all appear to fit into well-defined hierarchies, where we are protecting specific points of interest at various levels in these hierarchies (for example, humans are part of the animal kingdom but are separated out as a specific AoP).

My suggestion is to try to capture as much of this information as possible in this current chapter, as non-experts and as an introduction to the need to address this topic further, and then maybe have a workshop under the UNEP-SETAC initiative with some well recognized people from such disciplines as ecology to help provide a scientific foundation to LCIA.

David

P.S. I like anthropogenic interventions and the natural environment (or ecosphere).

*For **intervention** I find the dictionary definitions "1. the act or fact of intervening. 2. interposition or interference of one state in the affairs of another".*

*For **environment**: "1. the aggregate of surrounding things, conditions, or influences; surroundings; milieu. 2. Ecol. the air, water, minerals, organisms, and all other external factors surrounding and affecting a given organism at any time. 3. the social and cultural forces that shape the life of a person or a population. 4. Computers. the hardware or software configuration, or the mode of operation, of a computer system: In a time-sharing environment, transactions are processed as they occur. 5. an indoor or outdoor setting that is characterized by the presence of environmental art that is itself designed to be site-specific".*

C17: Willie Owens (16 February 2001)

Odum is a 'he.' And this is a truly classic text. Odum's points on the rates of energy and carbon flows in ecosystems as an indicator of their health - and the role of the number of organisms involved at each level in those flows - are essential concepts.

Willie

C18: Walter Klöpffer (16 February 2001)

Dear David,

thank you for trying to clarify some basic ecological terms. The problem with a purely ecological definition of safeguard subjects is, of course, that human on the one hand is part of the "animal kingdom", as you put it so nicely, on the other hand, however, clearly has a world of its own (which cannot exist without the kingdoms, ecosystems etc. etc.). We therefore need a word for this human world which causes all the trouble, call it economy, anthroposphere (Baccini & Brunner), technosphere (Frische, Klöpffer, Hofstetter, Weidema) or whatever. If humans would

just be part of the ecosystem, animals among animals and plants etc. we would neither need this distinction, nor LCA, and just enjoy the paradise.

I started to write not for that reason, but to give you the source of my critique of the term "ecosystem health". You can find a short discussion and a quotation [Suter II 1993] here in the "Global LCA Village":

Walter Klöpffer: Impact categories and category indicators - response

It was my response to the questionnaire sent around by Helias and Olivier in 1998 (between Bordeaux (April 1998) and Brussels (November 1998)).

Best regards

Walter

Reference:

Suter II, G.W. (1993): A Critique of Ecosystem Health Concept and Indexes. *Environ. Toxicol. Chem.* **12** (1993) 1533-1539

C19: Wolfram Krewitt (16 February 2001)

Dear all,

needles to emphasize again that I like the current discussion, that I like Erwin's and Helias' idea of finding a place for LSF in our LCIA framework (but I do it to avoid possible misunderstandings). I now feel that we start to turn in circles, which is partly unavoidable. The discussion developed its own dynamic, which is nice, but from my point of view it is lacking a link to the 'down'-part of the 'top-down' thinking. The 'top'-part is of basic importance, but it cannot/should not be discussed without considering also the 'down'-part. We are moving in an area which is highly value laden, influenced by different world views etc., so that perhaps we should not necessarily try to develop a universal, commonly accepted picture, as it is not surprising that we have different views on that level. I would like to see the discussion more in a 'what-if' manner. To point out very clearly what are the problems of the current AoP-framework, to make very clear why we feel we need LSF to be integrated, and to make clear what are the implications if we take over Helias' LSF approach, considering also the implications on impact categories, indicators, data requirements, ... - this is currently missing.

I think the current discussions show that Helias' and Erwin's suggestions for restructuring the AoPs cannot yet be considered as 'best-practice'. I would like to see Helias'+Erwin's chapter at the end of our common report/book, because it picks up problems arising from the work of the last years, and offers a possible solution. We should offer it as a possible direction for the future work, so we don't have to fix and to agree on everything now. But I would find it strange if we now decide on a new structure, a new terminology, and put this at the very beginning of a report summarising the work that was based on a different understanding of the basic framework.

Another comment on terminology: a large number of new suggestions appeared within the last weeks. The discussion is useful and necessary, but we should be careful in making quick changes. 'Ecosystem health' e.g. is a concept which is not new and well known in other scientific communities. It is good that David brought it up, but there might be also good reasons for why we did not use the term in our LCIA framework so far, so I'd be reluctant to take it over as a last minute change. When I some time ago - coming from a different working field, but partly doing similar things - tried to establish a closer link to the LCIA people, I had partly a hard time grasping the specific terminology of the LCIA community. We have to take care that the terminology is understandable to people outside of our limited discussion group, and we should also strive for a certain level of continuity in the terminology.

Wolfram

C20: Bengt Steen (20 February 2001)

Dear Helias, Erwin and everybody else on the list,

The amount of comments are by now considerable, and I am not sure I have been able to catch up with all that has been said, so if I boost any open doors, please have patience with me.

1. I think the text will benefit from a more clear declaration that we are discussing models of a reality. In the present text I get the impression that we discuss what part of the reality that belongs to various boxes. Of course a real object, like a person can be modeled in the economy, in the environment and in the technosphere.
2. To the definition of endpoints, I would like to add a clarification, like: This means that it should be observable and understandable for laymen.
3. In the five AoP:s suggested, I lack recreational values and aesthetical values. If 'Human health and welfare' was used as an AoP it would take care of this.
4. I would suggest that you do not add human health and animal health in one AoP. (As pointed out by Olivier) It seems less controversial to include it in 'Ecosystem health' together with 'Life support functions'. I would prefer Biodiversity to be alone an AoP as it was one of the main themes in Rio, and as it is a kind of 'top problem' of its own.
5. Finally my references as an eventual contribution to the introduction:

[1] Bengt Steen, Sven-Olof Ryding "The EPS Enviro-accounting Method", Swedish Environmental Research Institute, Report nr B 1080. Gothenburg 1992.

The report introduces 'end point modelling' and the 'Safe Guard Subject' concept into LCA.

[2] Bengt Steen "EPS-Default Valuation of Environmental Impacts from Emissions and Use of Resources. Version 1996" Swedish Environmental Protection Agency, Report AFR 111, April 1996.

This report is an update of the 92 report, with a improved modelling and more substances evaluated.

[3] Bengt Steen "A systematic Approach to Environmental Priority Strategies in Product Development (EPS). Version 2000 - General System Characteristics. Chalmers University of Technology, CPM Report 1999:4, Gothenburg 1999.

[4] Bengt Steen "A systematic Approach to Environmental Priority Strategies in Product Development (EPS). Version 2000 - Models and Data of the Default Method. Chalmers University of Technology, CPM Report 1999:5, Gothenburg 1999.

The reports contains updated and extended impact modelling and describe the method according to requirements and recommendation by ISO 14042.

Best regards

Bengt

C21: Helias Udo de Haes (23 February 2001)

Dear Colleagues,

It took some time, but attached you find the next draft of the chapter on AoPs. To be practical, we regard this now as final draft which will be sent to the two referees. Surely, they will have comments. If you also have comments, please send these to us, then we can deal with them in the same time as we deal with the comments from the referees. (The comments given by Bengt were the last we have included; Bo, sorry, I received your mail too late, but also without "red letters" in the edit function, so perhaps you sent the wrong attachment?).

What have we done? First of all a presentation of two ways to distinguish AoPs, a bottom-up and a top-down way. Secondly, we simplified the section on "system and environment", by distinguishing only between two levels: the product system and the total of product systems, i.e., the economy or technosphere. And we have tried to mention alternative terminology or alternative viewpoints on the relevant places in the text. We have stuck to the terminology as was used in the first report of the working group. New terminology should be chosen in the UNEP-SETAC initiative, or in the next round of ISO. The literature has still to be done.

We realise that this is only a step in the process, but think that the discussion has been quite relevant and interesting. So many thanks for the input! And the process surely will continue. One specific point: Figure 3 is quite complicated; it may be better to split it into two figures: one with the AoPs, and one with the relationships between AoPs, as was suggested by Erwin. By the way, we are quite open whether the chapter should be in the beginning or in the end.

Another point is that up to we have received just one other chapter, i.e., the chapter from Edgar et al. Edgar et al., thanks! But may I again ask the other authors to finalise your texts, and also to keep it as much as possible to the set length? There is a possibility that I lost some mail. So, if already more chapters have been sent, please send them to me again.

With best regards,

also on behalf of Erwin,

Helias

P.S. Nothing has been defined as yet on the format and lay out of the chapters. This has to be arranged with SETAC. But for the moment I propose to take the format we have also use in our SETAC report from 1996.

C22: Arnold Tukker (27 February 2001)

Dear all,

Busy with projects at TNO I necessarily was silent for a while in the AoP debate (but well, I'm just an agenda member...), decided to take the whole discussion with me this weekend to read things through, only to find out on Monday that a final draft had been circulated in the mean time. So maybe the reaction I wanted to give in the mean time is 'mustard arriving after dinner' (or 'moutarde apres le diner' for our French-speaking colleagues). But anyway. Here we go.

1. Like many others, I'm quite pleased that this debate now is held and admire the effort put into it by the editors of the chapter and the people who reacted thus far.

2. To some extent, I am surprised that WIA-2 is having this debate at its end of its existence - I would rather say that how you define your AoPs determines to a large extent how the rest of your impact assessment will be structured. I would like to refer to a dated, but in my view still very useful report written within the framework of the development of the Dutch EIA-methodology. They basically state that in EIAs you have to start to construct your evaluation framework (read Impact Assessment) by choosing 'AoPs', defining the related impact category end-points of relevance, deciding if you want to go for the true end-points or leave it with mid-points, etc. (ref: EIA, Assessment methods. Theory and Practice. EIA-series No. 13, Ministry of VROM, the Hague, the Netherlands, 1982).

Within this general context you can basically derive any environmental impact assessment tool you like (be it RA, LCIA, etc.; for who is interested I refer to my paper 'LCA as a tool in EIA' In Environmental Impact Assessment Review (20), 2000, p. 435). But of course I did not follow the debate in WIA-2 too close and maybe you all felt comfortable with the initial AoPs until very recently, and this was the reason why this discussion started so late.

3. What I like so much about the approach in that EIA methodology report is that it makes clear that how you define your AoPs and the related impact assessment method is basically a CHOICE. Of course not all choices will be as good as others. Of course once you have decided that the impact assessment needs to be used in the

context of LCA this limits the number of viable options. But yet, I think it is likely that it is possible to choose different categorizations of AoPs and related approaches to impact assessment, that are equally acceptable for use in LCA.

4. Point 3 is in fact reflected by much of the discussion. Some use as a criterion that damage needs to be caused by an environmental process (Erwin), others don't agree (David, Bo) or come up with alternative criteria (Patrick 9/2). Some use as an criterion that the system boundaries of LCIA should not be taken too broad, since this would make LCIA not practicable.

Several divisions and hierarchies for AoPs have been suggested (Bo, Olivier). Etc. There is the suggestion that the choice should be at least 'consistent' (Erwin). But what is consistent ? If for some reason I'm not interested in historical heritage (like we were in most EU countries in the 50s and 60s, see all the nice city highways we build over lovely canals then) in my LCA I leave damage to man-made structures out. If I'm just pleased with maintaining biodiversity, but don't care that 70% of a species dies, I leave 'animal health' out. Etc. It is quite difficult to sort out which limitations are inherently related to a kind of 'consistency' required in your structure of LCIA, and which limitations are 'choices' that can be defined in the goal and scope phase.

5. I'm therefore pleased that it is accepted that the chapter should not be too prescriptive. I believe (like Jane, Edgar, James ?) that in defining your AoPs and the related structure of Impact Assessment it will be very difficult to make a sharp distinction between 'value-laden' and 'scientific' choices. That I say this (see e.g. my book with Kluwer) is of course not so important, much more important is that this message is sent out already for 30+ years by mainstream policy science and philosophy of science.

6. Personally, I'm quite charmed by the effort of Edgar to structure LCIA according to the principles developed in Multi-attribute utility theory (MAUT; see Int. J. of LCA 6 (1)). This probably will not solve all questions, but at least will help to structure the choice/hierarchy of AoPs, the relation with impact categories etc. in a well-founded way. If additionally we will not fall into the trap to model in impact assessment only the emission-effect chain, but include as well proxy's that reflect the magnitude of our ignorance, and the extent to which effects are reversible, we're on track to what I see as my ideal LCIA (I deliberately say 'my', since I'm sure not all active and silent readers will agree - again proof how value-laden the whole current exercise is).

7. As one of my last a remark that is in one way down-to-earth, in one way philosophical. In some respect, I like the discussions as going on now, leading to an improvement of LCIA. Yet, I think it is very useful to be modest about what can be achieved, and to what extent further refinement of LCIA will truly contribute to better decision making. When we look at the about 8 impact categories that are currently playing a role in mainstream LCA (GWP, ODP, POCP, Ac., Eutr., Humtox, Ecotox, land use, resource use), the following observations can be made:

- ODP is almost obsolete in view of the ban of ozone depleting substances
- studies that try to contribute to debates where humtox and ecotox dominate

are totally frustrated by the 'framing' problem I described in my thesis (i.e. industry hammering on risk assessment, environmentalists and in the mean time also quite some policy makers now asking for more precaution), in relation to the weaknesses and data gaps in impact assessment of toxic releases; a problem I don't see solved by science, certainly not on short notice - land use and resource use still need an enormous amount of work before a generally accepted impact assessment is available; - the remaining impact categories can be covered by say 20 substances/interventions (if we use group parameters rather than individual substances for POCP; I'm not even discussing the point that geographical aspects are very important for Ac, POCP and Eutr., a point in many cases difficult to cover well in LCA).

It is no surprise that in many practical studies I see and review practitioners just use a very limited list of interventions in their LCAs, still providing good decision support since they simply state clearly in which areas LCA/LCIA is not powerful enough to underpin a decision scientifically. The whole idea about impact assessment is that somehow we reduce the information density that potentially could arise from the inventory via a structured weighting. But what do we gain if in practice just a few dozen interventions play a meaningful role in decision support by LCA, at the same time define a rather large number of AoPs to which they should be related, and the mathematical models to provide this relation contain very important uncertainties and ignorances? With this I don't want to say that WIA-2 should stop its useful work, but it does mean something about the extent to which its ideas and approaches can be prescriptive for other practitioners. I also believe it is useful if WIA-2 openly addresses the limitations of LCIA in its final document.

8. A last point in relation to point 2), the central nature of how you define AoPs for impact assessment, I would say that this would need to be the second chapter in the report of WIA-2 (after the introduction). The only reason to put it in an annex or so is that there is no consensus on how AoPs should be defined. A solution to this problem is to describe which steps can be taken to choose AoPs, impact categories etc., and then indicate which choice WIA-2 (implicitly ???) has made (since WIA inevitably has made a choice - in defining all headers for subsequent chapters on impact assessment categories, which leave out e.g. the now famous car accidents, etc.), a few ideas for alternative choices, etc.

Helias, Erwin, I don't need a detailed reaction on this, just save your energy to improve your document.

Regards,

Arnold Tukker