

Quantitative life cycle sustainability assessment using monetization

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Abstract RDC-Environment has developed a methodology based on life cycle assessment and monetization to evaluate in a quantitative way the environmental, social and economic impacts of a product, service or policy. Integrating the three pillars of sustainable development takes place through the concept of welfare (or well-being), depending on the quality of environmental, social and economic aspects. Using monetization, welfare is expressed in euro by assigning monetary values to the following final effects: length of life and quality of life (including available resources, health, (dis)amenities and utility of consumption or available time). The methodology brings consistency in the assessment of the three pillars by ensuring a similar meaning to 1 euro, i.e. the additional welfare brought by 1 euro of additional income to a mean European, as well as by determining the chains of effects for associating to each type of impact an amount of final effects, reflecting the actual consequences of an activity.

1 Introduction : Context and objectives

Pressure coming from consumers and public authority has increasingly pushed private and public decision makers to account for sustainable development (SD) in their decisions. The integration of several dimensions in decision making is facilitated if a weighting between the various pillars can be introduced. For assessing the economic, environmental and social aspects of a product or project, such quantitative methods need further improvements.

Rating and monetizing are two weighting methods in use in sustainability assessment. Rating is typically applied to evaluating sustainable investment performances of companies. It suffers from a lack of transparency and weak linkage between actual impacts and results since relative weights of the various pillars are often predetermined and do not depend on the actual amplitude of each dimension impacts. In terms of monetizing, cost-benefit analysis studies and

literature exist but it requires further attention for adequate integration of the considered elements.

The methods presented in this paper are based on monetizing. RDC Environment has developed methodologies and datasets for attributing monetized impacts to products or projects in terms economic, environmental and social aspects ([1] for environmental impacts). They are used in the framework of a life cycle approach. The methods aim at answering two types of questions, depending on the goal of the assessment:

"What are the impacts of the product, service or policy on my country/region in terms of sustainable development? "

"What is the total cost of this product for the environment and the human beings?"

2 Approach

2.1 Welfare and single unit

The sustainability of an activity is assessed through the amount of welfare it represents. Welfare is quantified in a single, monetary unit, euro. €1 welfare is equal to the additional welfare one extra euro brings to a mean revenue person.

2.2 Two different questions

As presented in the introduction, the sustainability assessment can be carried out with different goals. The purposes of answering the following two questions are distinguished in this paper.

The first question concerns the welfare associated to an activity on a particular territory, i.e. the population welfare in a territory which we can allocate to the assessed activity. In other words, the goal is to determine which of the population welfare of a territory is attributable to an activity. Let us call it the impact question.

The second question concerns the social cost, i.e. the global burden in terms of welfare of a product or project life cycle. Let us call it the cost question.

We show in the two following paragraphs how we define welfare modifications through final effects and how these final effects refer to the three pillars of sustainable development. In other words, we show that our assessment in terms of

welfare consists in a sustainability assessment. As we identified two different questions, two different assessments are possible.

2.3 Two different sets of final effects determining welfare

An activity can influence welfare through its final effects, i.e. the ultimate effects on the human beings. We consider that ultimate effects on human beings regard the duration of life, life length, and the quality of the years of life spent, quality of life. As discussed below (cf. **Error! Reference source not found.**), these final effects can originate from one or several of the three SD pillars.

As two different questions were identified, the two sets of final effects determining welfare differ, as presented in Table 1. The list of final effects regarding quality of life is conventional and could be modified during further developments of the method.

Table 1 : Final effects

Impact	Cost
<i>Life length</i>	<i>Life length</i>
Years of life lost	Years of life lost
<i>Quality of life</i>	<i>Quality of life</i>
Available resources	Available resources
Health	Health
(Dis)amenities	(Dis)amenities
Utility of consumption	Available time

2.4 SD pillars and final effects

Final effects occur through the three SD pillars, in the way explained below for the two distinct questions.

2.4.1 Impact question

The impacts taken into account are the following, according to each SD pillar:

- Environmental welfare is linked to environmental damages on human beings, through years of life lost, health, (Dis)amenities, resource consumption.
- Economic welfare is linked to the welfare brought by consumption of the population of the territory made possible by available income.

- Social welfare linked to (dis)amenities from job creation and job quality
- As the assessment focuses on a territory, only the local impacts are taken into account, except for the environmental impacts, which are considered as being intrinsically global as the environment is a global public good.

2.4.2 Cost question

The costs taken into account are the following, according to each SD pillar:

- Environmental welfare is linked to environmental damages on human beings, through years of life lost, health, (Dis)amenities, resource consumption. Only external costs are taken into account, i.e. costs that are not reflected in the market prices.
- Economic welfare cost refers to time and resources consumed in the activity assessed. The cost comes from the fact that if time and resource are used in this activity, it cannot be used in another activity. These consumptions are valued at opportunity cost.
- Social welfare linked to (dis)amenities from job creation and job quality. Only external costs are taken into account.

Note : Considering available time as a limited resource does not mean that a low labor intensive product will always be preferred to the same product produced in a high labor intensive way, other things being equal. Indeed, social aspects, e.g. job creation, are taken into account, so that a high labor intensive product could be preferred to the same product produced in a low labor intensive way if, for example, the production implies job creation.

2.5 Monetizing the final effects : Non-market goods valuation

Monetizing consists in putting a price on a good which either has no price (e.g. health), or has a price that does not include externalities (e.g. when you pay for a car, you do not pay for the noise you impose to the neighborhood). Monetizing aims at assessing the total economic value, made up from use and non-use value. Methods that allow for non-market goods valuation are generally divided into revealed and stated preferences methods. These methods have been largely discussed in the literature, e.g. in Pearce et al. (2006). They are used for valuating the final effects.

3 Specificities of the method

3.1 Life cycle thinking approach

The assessment concerns every step involved in the life cycle of the activity assessed, from the extraction of base materials to end-of-life. This is true for the three SD pillars.

3.2 Impact pathway approach

Using the impact pathway approach, we get physically as close as possible from the actual effect on human beings (the final effect) before monetizing it. The impact pathway approach consists in determining the impact of an elementary flow (for example, the emission of 1 kg of a specific pollutant) by following its pathway, i.e. the chain of effects until occurrence of the final effects on human beings. This can be typically illustrated in the case of atmospheric pollutants. The steps are the following:

- Emission, e.g. kg of pollutant in the air
- Dispersion, e.g. g/m³ of pollutant in the air in the impacted area
- Exposure, e.g. number of people that ingested a certain quantity of pollutant
- Dose response function, e.g. number of years of life lost and number of people suffering from health problems (final effects) in the population due to the ingestion of the pollutant
- Monetisation of the final effects.

The impact pathway approach is namely developed in the series of ExternE and subsequent projects of the European Commission [2].

3.3 Management of the repair/prevention activity

When the impact pathway includes a repair activity, we integrate the repair activity into the model of the activity assessed, so that the impact of this activity and the residual impact of the first activity can be fully accounted for. An example of such case is represented by the liming of lakes, a repair activity caused by the emissions of acidifying substances.

4 Advantages and originality of the method

4.1 Monetizing : diminishing uncertainty by filtering information

Unlike assessment with multiple units, a single unit such as the monetary unit allows for a direct perception of relative importance of impacts. This prevents the assessor from deepening negligible steps and helps him/her to focus on the most important steps. Hence, uncertainty can be diminished.

4.2 The impact pathway approach in the valuation method

While other monetization methods apply declared methods directly on elementary flows, we use the impact pathway approach. We hence follow the chain of effects in order to get physically as close as possible from the actual final effect on human beings (the final effect) before monetizing it, in order to gain in robustness. Indeed, for example, the damage linked to a cancer is easier to consider than the one linked to a 1 kg of emitted cadmium. We think that uncertainties linked to physical models are less severe than errors linked to lack of knowledge of people whose revealed and declared preference are analyzed.

4.3 Management of the repair/prevention activity

Integrating repair and prevention activities in the model allows for the accounting of the externalities of those activities, generally not taken into account in the literature.

5 Methodology for the three pillars

As mentioned above, according to the question the assessment wants to answer to, different approaches are possible. This section shows the different assessment methods developed for each SD pillar, while the section “Sustainability performance result” shows how to combine the methods in order to give the right answer to the question. Note that the base method is the same for both questions

for the environmental and the social pillars, while the method for the economic pillar differs with the question.

5.1 Environmental cost / Environmental impact assessment

Environmental evaluation is carried out in the life cycle analysis (LCA) framework. This implies:

- 1) Environmental impacts of all the activities belonging to the life cycle of the product, service or policy are taken into account, according to the cut-off criteria.
- 2) All impacts are based on the elementary flows linked to the concerned impact category.
- 3) The impact pathway is traced, which defines the physical link between the elementary flow and the physical impact on human beings, e.g. number of cases of cancer, number of years of life lost. This physical impact is called final effect. In some cases, this link can be established for an entire impact category, directly from the link determined for the reference flow of the category.
- 4) The economic value (€) of the final effect is computed through monetizing, using revealed and/or stated preferences.

Note: When conducting a cost assessment, only the environmental costs that are not reflected in the economic pillar assessment are taken into account, i.e. the external costs. Double counting with the economic pillar is hence avoided.

The final effects associated to the environmental evaluation are Years of life lost, Health, Resource availability, (Dis)amenities. Available time and Utility of consumption can be affected through the modeling of a repair activity, hence through the economic pillar.

5.2 Social cost / Social impact assessment

Social aspects are concerning several target groups, i.e. workers, the society, consumers and local community. The methodology is focused on the effects of jobs on workers and the society. The following elements are taken into account.

- 1) Job creation is considered as increasing social welfare, as it (1) improves social integration and (2) diminishes unemployment allowance as well as increase perceived income tax (in practice, (2) is to be accounted for in the economic pillar). Job creation valuation is based on the subsidy given

by some authorities to organizations who create jobs. This premium reflects the society's willingness to pay for job creation.

- 2) Job quality improvement is considered as increasing social welfare. Health, security and training are valued.

Only local social effects are taken into account in the social impact assessment, while all social effects are taken into account, without geographical boundaries, in the social cost assessment.

Use value, i.e. the welfare brought by the product to the consumer or by the activity to those who benefit from the output of the activity, is not taken into account in the presented method.

Note: When conducting a cost assessment, only the social costs/benefits that are not reflected in the economic pillar assessment are taken into account, in order to avoid double counting with the economic pillar. For example, risk is a social cost, which can be economically compensated by a risk premium. If this premium is considered as a good proxy for the social cost, then it has to be accounted either in the economic pillar or the in the social pillar, but not double counted.

5.3 Economic evaluation

Economic evaluation differs fundamentally whether an impact or a cost assessment is leaded. The difference in terms of final effects has already been mentioned in Table 1.

5.3.1 Economic impact assessment

The objective of the economic impact assessment of an activity is to assess the associated economic welfare of the population in a given territory. The economic welfare is defined as the welfare (utility) associated to consumption, made possible by available income.

The variation of economic welfare is assessed through

- The estimation of available income variation of the population of the given territory
- The correction of the available welfare for distributional effect, according to the hypothesis of decreasing marginal utility of available income.

This way, 1€ additional welfare can be interpreted as the additional welfare brought by 1€ extra income for a mean income citizen.

1) Estimation of available income variation

An activity (in our context) implies a transaction between two agents, the seller and the buyer, in a defined territory. The amount the seller gets can be regarded as an injection in the domestic economy, what is allocated between

- his domestic and foreign employees (supposed to live in the domestic territory)
- his domestic subcontractors (for both private and professional consumption)
- his foreign subcontractors (for both private and professional consumption)

Then, the subcontractors and employees have their own allocation between these 3 categories, and so on.

Finally the total impact can be divided according to the following table.

Table 2 : Economic impact typology

Type of impact	Meaning
Direct impact	Income of the domestic employees of the seller
Indirect impact	Income of the domestic employees of the subcontractors of the whole contract chain
Induced impact	Domestic income linked to the final consumption by employees reached by direct and indirect impacts
Total impact	Total domestic income linked to the injection

The economic impact of the injection is the sum of the incomes of domestic employee all along the contract chain at the seller side of the good concerned.

This estimation can be carried out using the economic base model or the input/output model, depending on data availability and the scale of the economic territory.

Note: As the amount received by the seller does partly come from the inside of the territory, the “negative” impacts of the financing side have to be regarded. This is explained in the example below.

2) Estimation of economic welfare variation

Marginal utility of income depends on the initial income. So, additional income of each individual is weighted using welfare weights, defined by the following equation, borrowed from [3]:

$$a_i = (\bar{Y}/Y_i)^e$$

with a_i the i th individual welfare weight, Y the income and e the marginal utility of income elasticity.

5.3.2 Economic cost assessment

Economic cost assessment consists in computing the cost price, i.e. the opportunity cost of resources and time spent on the production of a product/service or project. Time spent on production is considered as a decrease in available time for other activities. Of course labor time has a social utility (integration), that is conventionally valued in the social pillar, as well as the utility of job creation. The market price excluding tax is the base estimate of the cost price we are looking for, if we assume the market does not fail in pricing time and resources. Excluding all sorts of taxes and subsidies prevents from double counting environmental and social externalities internalized by taxes and subsidies.

6 Sustainability performance result

6.1 Impact of an activity in terms of welfare

Hypothetically, an activity is financed by substituting it to another activity. So, the impact assessment is a comparison between the economic, social and environmental impacts of the assessed activity and the substituted activity. If the substituted activity is known, it is modeled, if not, it is assumed to have “mean” characteristics, based on the total SD impact of the country per GDP.

The result is computed as follows, with a : the assessed activity, and s : the substituted activity:

Welfare impact a = Economic impact a – Economic impacts + Local social impact a
– Local social impacts + Environmental impact a – Environmental impacts

6.2 Cost of an activity in terms of welfare

The result is computed as follows, with a .:

Welfare cost a = Economic cost a + Social cost a + Environmental cost a

6.3 Differences between impact and cost assessments

6.3.1 Global vs. local

Cost point of view is global while impact point of view is local, except for environmental issues.

6.3.2 Economic and social efficiency

Cost valuation assesses the social burden of the activity. If you have two activities with the same output (e.g. a computer), the one with the least social cost will be globally preferable as it consumes less resources and/or time and/or provokes less diseases, etc. The production is socially more efficient.

With the same activity assessed (production of a computer), the impact assessment would focus on the local impact of the decision to buy a computer instead of another. The computer bringing more welfare locally will maybe be the one involving the most old-fashioned, time consuming technology.

6.3.3 Distributional effects

The cost assessment does not take explicitly distributional effects into account, except under the form of job creation, while impact assessment does take distributional effect into account.

7 Further developments

Use value, i.e. the welfare brought by the product to the consumer or by the activity to those who benefit from the output of the activity, is not taken into account in the presented method. This prevents the use of the methods for assessing, in the absolute, the sustainable score of a product or service. Methods can however valuably be used for providing results in the framework of a between similar products or activities. A method able to take the use value into account has to be developed in the future.

8 Conclusion

The need for assessment methods able to value the sustainability of activities has recently been rising, hence taking economic, social and environmental aspects into account. To decrease the complexity of both private and public decision making, quantitative methods including a weighting of the contributions from the various pillars are required.

This paper presents such methods developed by RDC Environment to answer the two types of question the decision makers are typically facing. The first addresses the impact of an activity and the second regards the cost of an activity. Life cycle approach is used for the assessment of the three pillars, as it prevents from transferring impacts from one producing phase to another.

Our method is based on the assessment of welfare variation due to the activity through final effects on human beings. Final effects cover the three pillars of sustainable development and slightly differ with the type of question. The final effects are linked to the studied activity by looking at the actual chain of consequences.

Welfare variation is expressed in a single unit, euro. This approach necessitates the use of non-market valuation methods but is considered to decrease uncertainty and facilitate decision making.

The methods have been successfully applied to case studies in the waste management sector.

However, a method able to take the use value into account has to be developed in the future.

9 References

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